BEST MANAGEMENT PRACTICES

Pesticide Storage, Handling, and Application

Agriculture and
Agri-Food Canada

Ontario
Ministry of Agriculture,
Food and Rural Affairs

What is a Best Management Practice (BMP)?

- a practical, affordable approach to conserving soil, water and other natural resources in rural areas
- can also be an applied technology to enhance farm production without sacrificing soil and water resources

Who decides what qualifies as a BMP?

- a team of farmers, researchers, natural resource managers, extension staff and agribusiness professionals

What is the BMP Series?

- innovative, award-winning, full-colour books from 36 to 150 pages – some titles may have related videos, and/or slide sets
- each book presents a range of circumstances and options to address a particular environmental concern – use the information to assess what's appropriate for your property
- the titles are:
  Farm Forestry and Habitat Management
  Field Crop Production
  Fish and Wildlife Habitat Management
  Horticultural Crops
  Integrated Pest Management
  Irrigation Management
  Livestock and Poultry Waste Management
  No-Till: Making It Work
  Nutrient Management
  Nutrient Management Planning
  Pesticide Storage, Handling, and Application
  Soil Management
  Water Management
  Water Wells

How do I obtain a BMP book?

- single copies of each title are available at your local Ontario Ministry of Agriculture, Food and Rural Affairs office – some titles may also be available at select Conservation Authorities and district offices of Ontario Ministry of Natural Resources
- otherwise, for single copies, bulk orders, and complete sets of BMP books and related materials, contact: Ontario Federation of Agriculture, Attn: Manager, BMP, 40 Eglinton Ave. E., 5th flr., Toronto, Ontario, M4P 3B1. Phone: (416) 485-3333; fax: (416) 485-9027

Prices vary per title and with quantity ordered.

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A word about measurement...

In this book, most metric units are presented with approximate imperial equivalents immediately following in parentheses. Occasionally, where common usage or common sense dictates, only one of metric and imperial appears.

INTRODUCTION

Pesticide products are very useful tools in agricultural production. Used correctly, they contribute to higher productivity and higher quality characteristics in crops. By protecting crops from pests, pesticide products also contribute to the economical, safe, and nutritious variety of foods consumers enjoy.

As well as the benefits of pesticide use, there are risks to humans, livestock, wildlife, and the environment. Potential problems can be avoided by understanding these risks and knowing how to manage them.

The intent of this book is to help you learn how to store, handle, and apply pesticides in a safe and cost-effective manner. The next two chapters describe the details of storage and handling structures as well as the management practices to make them work. The final chapter describes the principles of application, how to select and care for application equipment, and the best management practices to keep products on target and out of natural resource areas.

For the purposes of this book, a **pest** is any harmful or troublesome organism that causes an unacceptable level of loss in crop yield or quality. Pests include weeds, insects, diseases, or even animals such as rodents or deer. A **pesticide** is any chemical designed to kill or control a pest. The emphasis in this book will be on insecticides, fungicides, and herbicides.

BIOLOGICAL CONTROL

BioPol
BioPol

Parasites are used to control white-fly in greenhouses. This is a biological method of pest control, where a living organism is being used to kill another living organism (i.e., the target pest). Predators of the pests are introduced to the crop.

GENETIC IMPROVEMENTS

Roundup Ready
CORN
"ROUNDUP READY" CORN
MONSANTO
TECHNOLOGY
FOR THE
FUTURE

More modern methods of control involve genetic engineering of the crop to give it natural resistance to a pest. Other examples are the release of sterile insects, and breeding disease-resistant and herbicide-resistant plant varieties (shown here).

PHYSICAL CONTROL

Physical control removes the pest from or prevents its entry into the crop. Power vacuuming, propane flaming, and plastic-lined trenches (above) have been tested against the Colorado Potato Beetle. Cultivating weeds is another means of physical control.

CHEMICAL CONTROL

The application of pesticides by sprayers is a chemical method of pest control. Pesticides are substances used specifically to control pests like insects, weeds, or diseases.

CULTURAL CONTROL

Crop rotation and the use of disease-resistant varieties of crops are examples of cultural control.

INTRODUCTION

Proper use of pesticides helps create high quality farm produce.

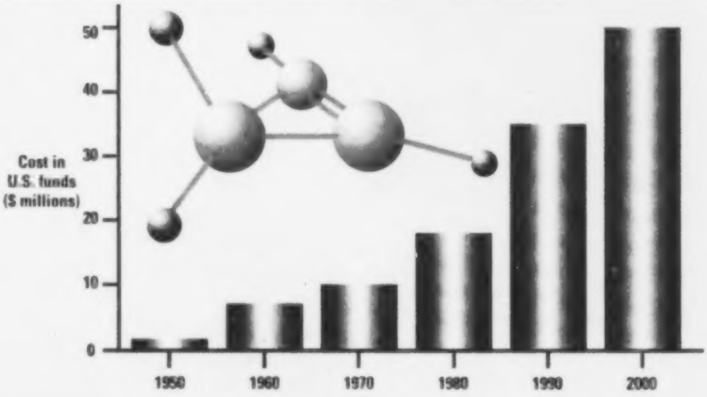
A CENTURY OF DEVELOPMENT

Our ancestors fought pests using their hands, mechanical tools, animal-powered equipment, and finally mechanical power. Early pesticides included salt, sulphur, bluestone, lime, mercury, ashes, copper, lead, and arsenic. Around 1900 we started to use industrially processed chemicals for pest control, and enormous advancements have been made since that time.

Following World War II, new manmade pesticides dramatically changed the practices of pest control forever. The chemical 2,4-Dichlorophenoxy acetic acid (2,4-D) allowed the first large-scale control of weeds in corn and cereals. The organochlorine insecticides revolutionized insect control by providing effective control of many crop- and life-threatening insect pests with relatively low toxicity to humans. Triazine herbicides like simazine, atrazine, and cyanazine allowed farmers to grow much larger areas of corn with all the attendant benefits to food and livestock production. Organophosphate and carbamate insecticides, ethylene-bis-dithiocarbamates (EBDCs), and Captan-like fungicides greatly improved horticultural crop production practices, as well as those for field crops, by the early 1960s.

Of course there were some problems identified with this otherwise positive trend in agriculture. Pesticides affected other organisms that were not the target of the treatment. Spilled pesticides contaminated ponds and streams when care was not taken during storage and handling. Wildlife, primarily fish and birds, were negatively impacted when persistent or bio-accumulating chemicals got into their food chain or primary habitat. Certain classes of pesticides had an acute risk to humans, resulting in cases of mild to severe poisoning.

PESTICIDE DEVELOPMENT COSTS



New pest control products are subjected to rigorous efficacy, environmental, and safety testing. The process takes several years and many millions of dollars.

INTRODUCTION

To overcome many of these problems, farmers along with government, industry and university toxicologists cooperated to develop methods to better evaluate environmental impact and human toxicity before a product was introduced. Each new pesticide is rigorously tested before it reaches the market – taking seven to 10 years and costing up to $100-million. Researchers and regulators now have much more reliable information on toxicity residue levels in food, and the fate and longevity of pesticides in soil and water. This knowledge helps establish whether the benefits of the product outweigh the risk and under what conditions the product may be used to minimize those risks.

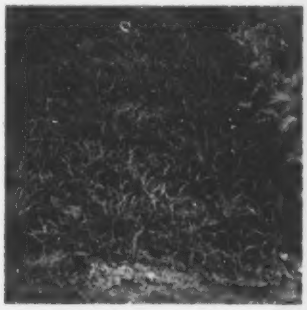
An even more promising development in the last decade is the production of narrower spectrum and low-dosage pesticides. Although these are positive trends, with each product we must be aware of any negative characteristics possessed by the specific product or product group. These products are gradually replacing the older ones. Industry now equips farmers with safer, more effective pesticide products than ever before.

The average citizen may not recognize the impact of pests on the food supply. Worldwide, losses due to plant pests are high: field and storage losses are estimated to be as much as 40% – in spite of a multitude of pest control options.

BENEFITS

When used properly, pesticides provide an economical method of managing pests in just about every crop produced in Ontario. They provide the following benefits:

- crop protection from damage and yield losses due to competing organisms
- moderate- to low-cost control method
- improved product quality
  - blemish-free fruit
  - insect-free vegetables
  - higher-yielding grain crops
- harmful pests, some of which produce human disease and dangerous toxins, prevented from reaching our food supply
- improved harvestability when weeds and other pests are controlled
- improved yields on productive land
- more choices in crop production
- part of an integrated approach to controlling pests.



Herbicides can be used to prevent weed infestation – or rescue food crops from failure.

Growers can learn about the safe use of pesticides through pesticide safety workshops.

Consumers expect blemish-free fruit and insect-free vegetables. Pesticides help control damage to high value crops.

INTRODUCTION

Risk = Toxicity x Exposure

Some pesticides that protect crops can be directly harmful to wildlife. Choose chemicals with less toxicity. This carcass of a Mallard duck was found in a cabbage field treated with insecticides.

It's industry's responsibility to test and determine the conditions under which pesticides may be used safely.

RISKS

Certain pesticides, when they are not stored, handled, or applied properly, can lead to:

- human exposure to toxic materials, which may cause injury, death, or long-term health effects (e.g., cancer, asthma)
- contamination of water, air, soil, and habitat
- direct wildlife exposure to toxic materials that may harm natural predators, pollinators, beneficial soil organisms, fish, birds, and other wildlife – particularly with spills, but also with drift and leaching into water bodies
- bio-accumulation of some products in body tissues – this presents a risk to the food chain
- excess residue on food through overuse and/or improper timing of use on food products such as fruits and vegetables – this could lead to seizure of the crop
- pest resistance, which occurs when the same material or products within the same chemical group are used continually
- economic losses due to crop damage or poor pest control
- disruption of natural control agents. Many pesticides are non-selective and upset the predator-parasite balance. The removal of natural pest control increases dependence on chemical pesticides.

CHARLIE BEE
F17527

It's the responsibility of pesticide users to read and follow label instructions, and handle and use the products wisely. Not doing so poses risks to key beneficials such as pollinators.

INTRODUCTION

FATE OF PESTICIDES IN THE ENVIRONMENT

Pesticides dissipate at varying rates. Simple chemicals often dissipate more quickly than complex chemicals.

The physical and chemical properties of pesticides influence their potential to harm the environment. The most important properties to know are:

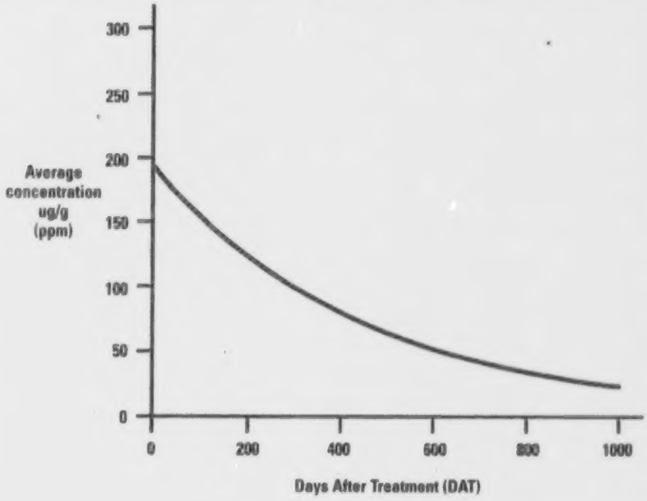
- **degradation** – ability to break down in the environment
  - the longer a pesticide takes to degrade, the greater the risk for water contamination
  - generally, complex chemicals like some organophosphates last longer since they can't be broken down readily by soil microbes
  - soil conditions that provide excellent habitat for microbial growth may also lead to more rapid rates of degradation
- **volatility** – ability to move into the air, e.g., hormone herbicides
- **solubility** in water – ability to leach into groundwater, e.g., metalochlor can leach more readily than atrazine
- **adsorption** – binding characteristics with soil particles, e.g., triazines bond to soil particles
- **absorption** – ability to move into organisms or structures
- **bio-accumulation** – ability to accumulate in body tissues.

These properties, combined with processes such as runoff, leaching, wind and water erosion, and vapour drift, determine what happens to a pesticide and where it ends up after it's released into the environment.

Glyphosate (found in products such as Roundup® and Touchdown®) is a simple chemical and will break down readily or will be rendered inactive by soil adsorption.

Negative impacts on the environment can be greatly reduced if chemicals are stored and handled safely. Further, proper application techniques that ensure pesticides are used at the right pest stage, at the right time, and on target will also reduce environmental impact.

HOW PESTICIDES DEGRADE



When present in soil, pesticides degrade over time. Dissipation is the lowering of pesticide concentrations in a specified area (soil, plant, atmosphere) due to the combination of biological, physical, and chemical activities such as photodecomposition into other chemicals.

INTRODUCTION

PHOTODECOMPOSITION – some of the foliage and soil-applied pesticides can be broken down by sunlight into other chemicals.

EVAPORATION – some of the spray products applied under warm and dry conditions may be vaporized before reaching the target.

VOLATILIZATION – some pest control products (both plant-applied and soil-applied) and their adjuvants are quite volatile and may be lost to the atmosphere before reaching target pests. Some products, such as soil fumigants and pest control products for stored grain, work best if volatile.

RUNOFF – dissolved, suspended and adsorbed pesticide products can run off farmland in the event of a spill or with snowmelt and heavy rains.

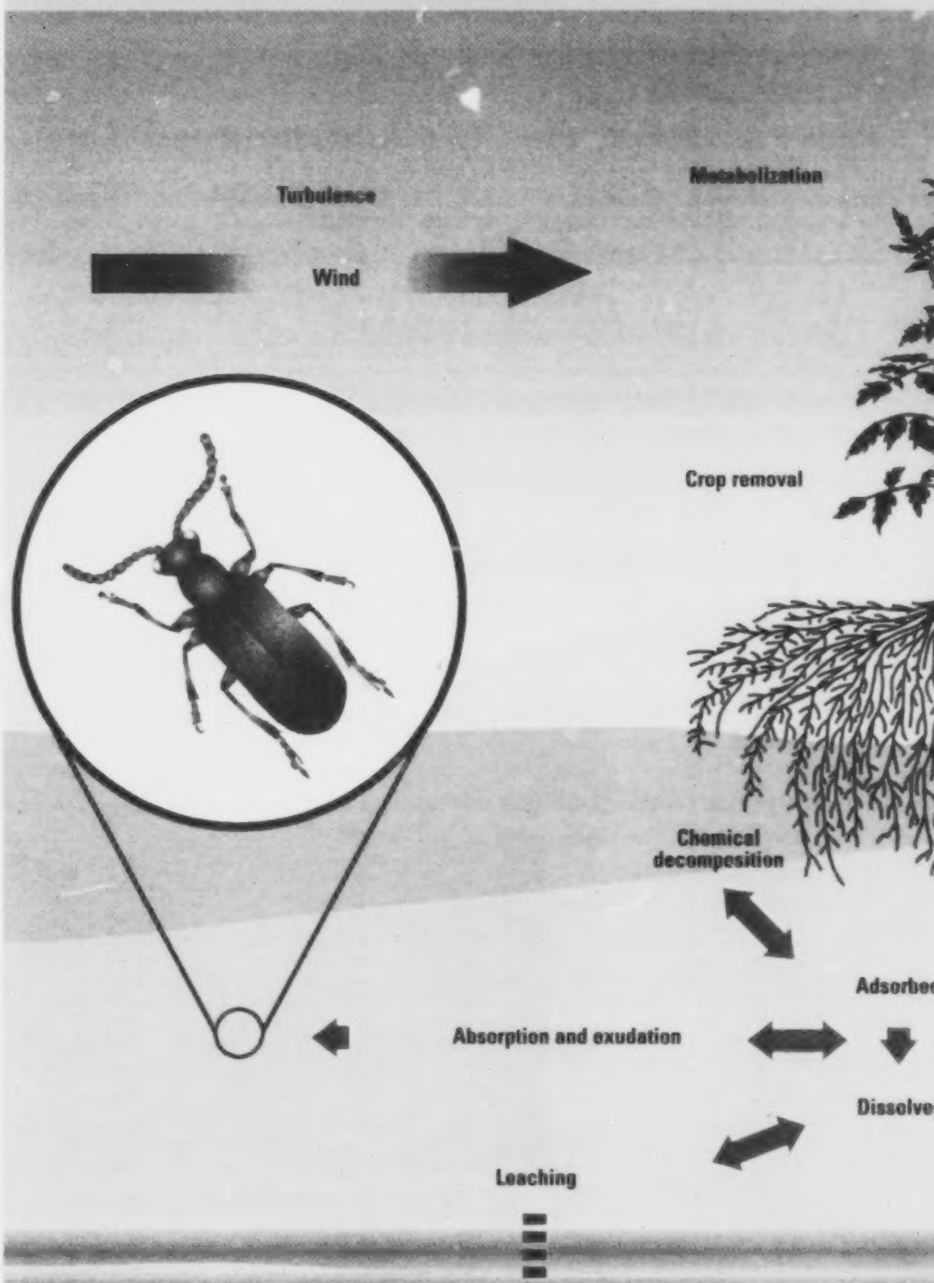
TURBULENCE – air currents and winds can move sprayed products off-target and keep them in suspension.

CROP REMOVAL – some materials will remain on or be absorbed into the harvested crop.

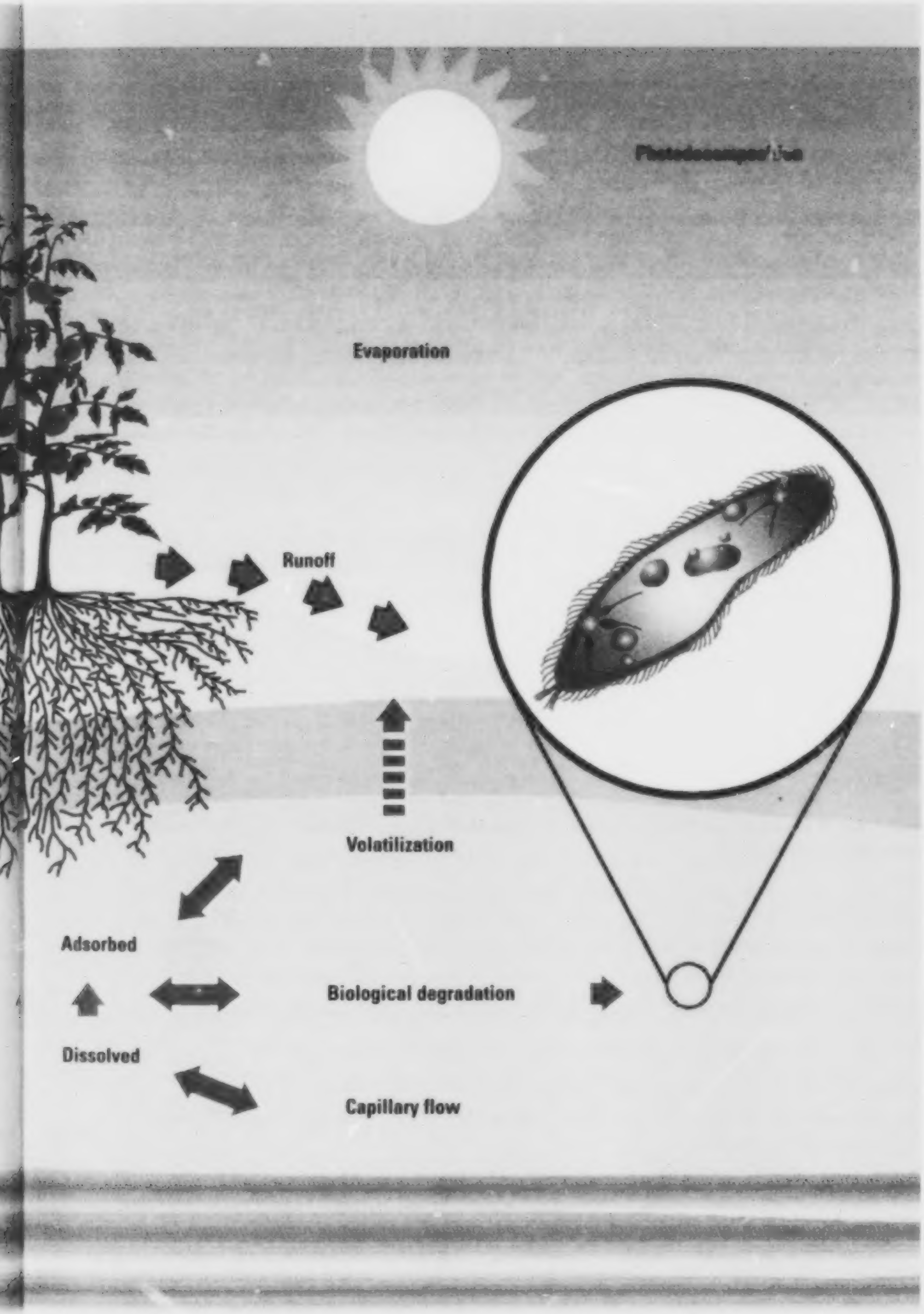
METABOLIZATION BY PLANT – plant will take up some of the chemicals. Here, the chemical will be metabolized, perform its task, and be degraded by the plant.

ABSORPTION AND EXUDATION – target insect pests and non-target animals can absorb pesticide products – orally, through the skin, or through respiration. These chemicals can perform their intended function, bio-accumulate in non-target pests, or be excreted (exudated).

FATE OF PESTICIDES IN THE ENVIRONMENT



INTRODUCTION



ADSORPTION – pesticides and their breakdown products can become attached to negatively charged soil particles, i.e., humus and clay. Attached materials can be volatilized, absorbed, decomposed by chemical or biological means, remain attached, or dissolve in the soil solution.

CHEMICAL DECOMPOSITION – chemicals in the soil, such as lime and naturally occurring acids, can break down pesticide chemicals.

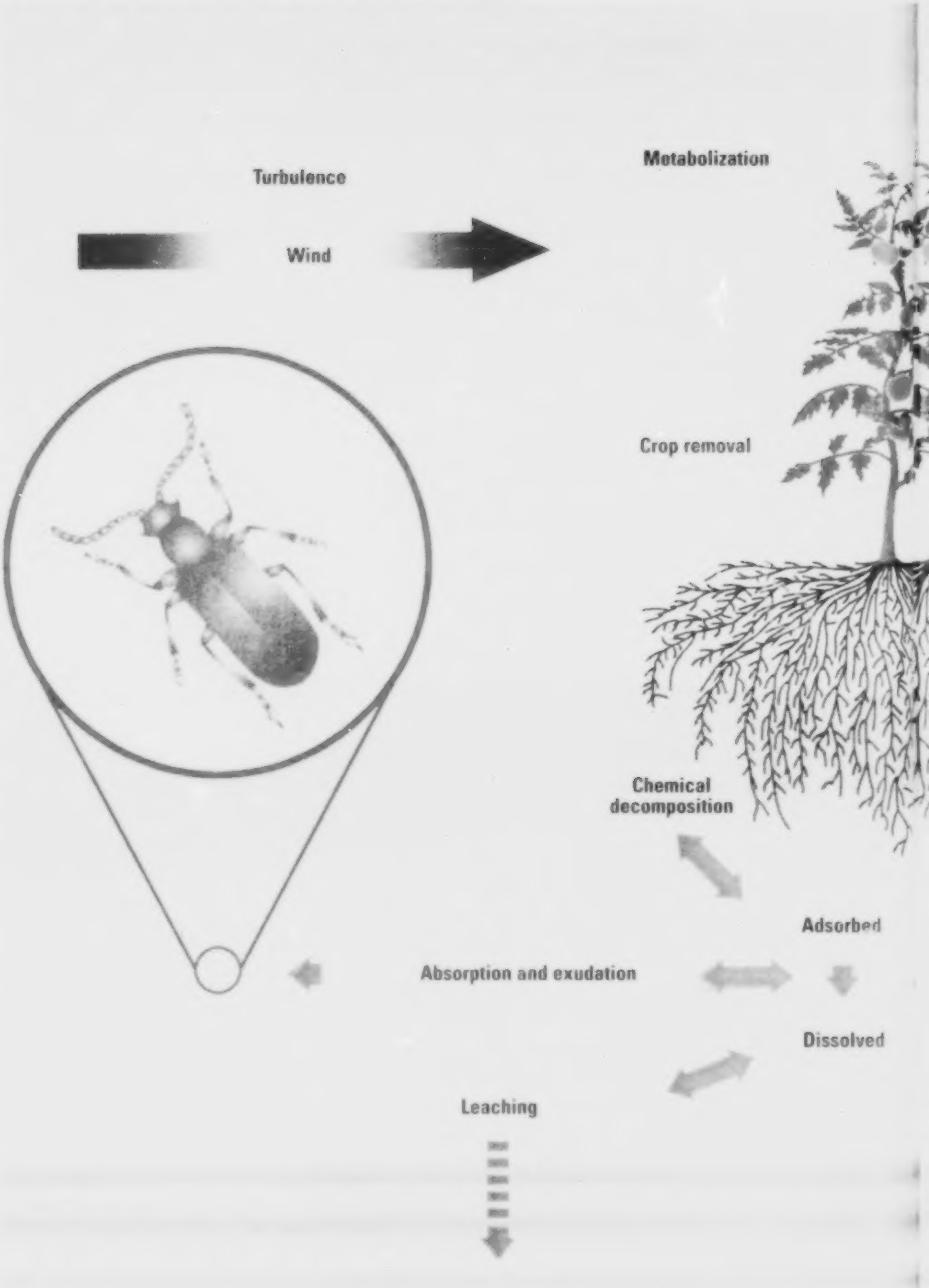
BIOLOGICAL DEGRADATION – soil microbes and other living organisms can use their own enzymes to degrade pesticides and break down products.

DISSOLVED – soluble (salt-like) chemicals can become part of the soil solution. Soil solutions can continue to interact with soil chemical and biological processes or be lost by leaching and runoff.

LEACHING – soluble pesticides and their breakdown products can percolate through the soil by gravity and reach the water table. Aquifers can be contaminated by very minute amounts of these products.

CAPILLARY FLOW – products can move with soil solutions and soil water upwards and laterally due to soil pore sizes and continuity of pores. In this way, pesticide products can be "recycled" through the soil medium and be subject to all the above fates.

FATE OF PESTICIDES IN THE ENVIRONMENT



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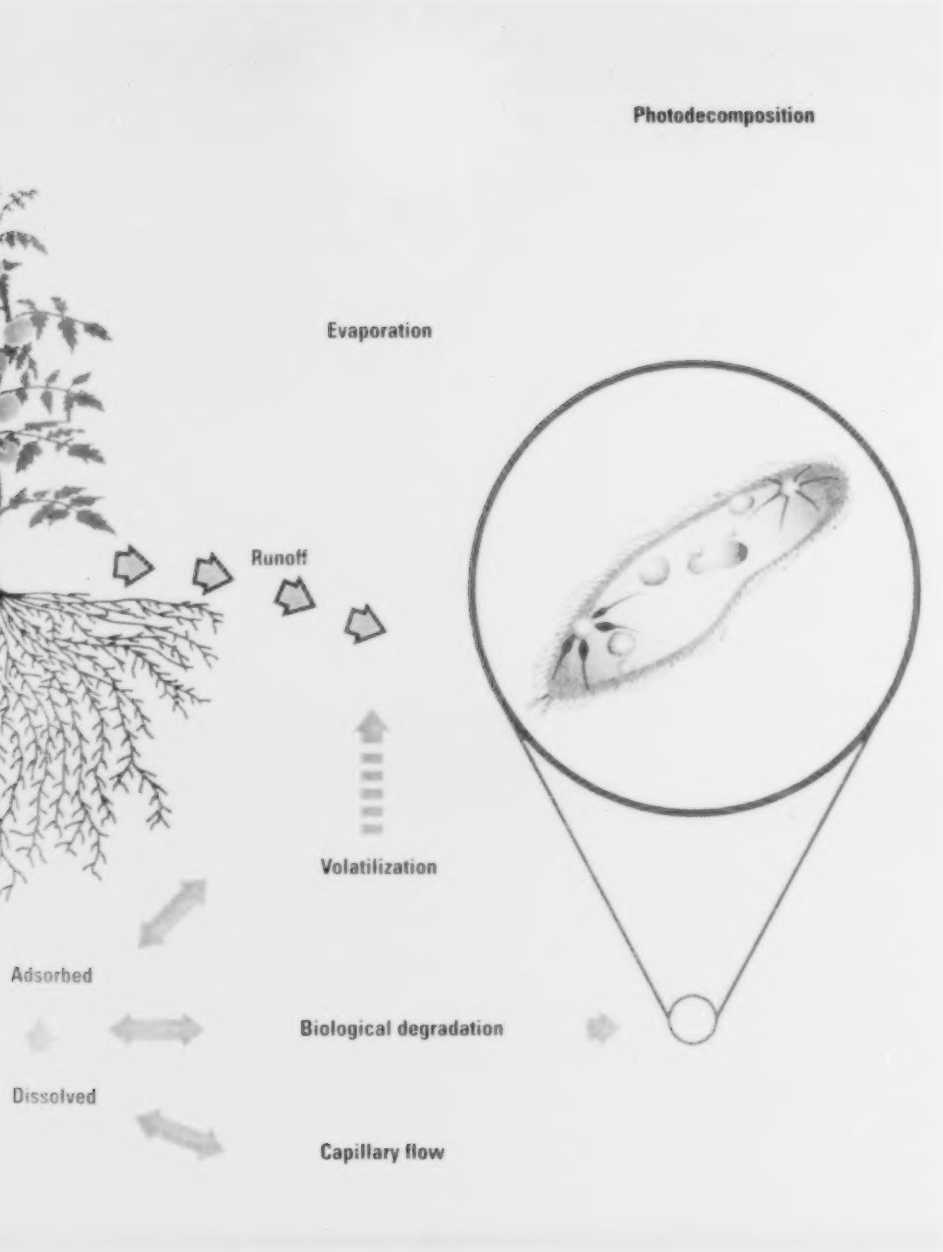

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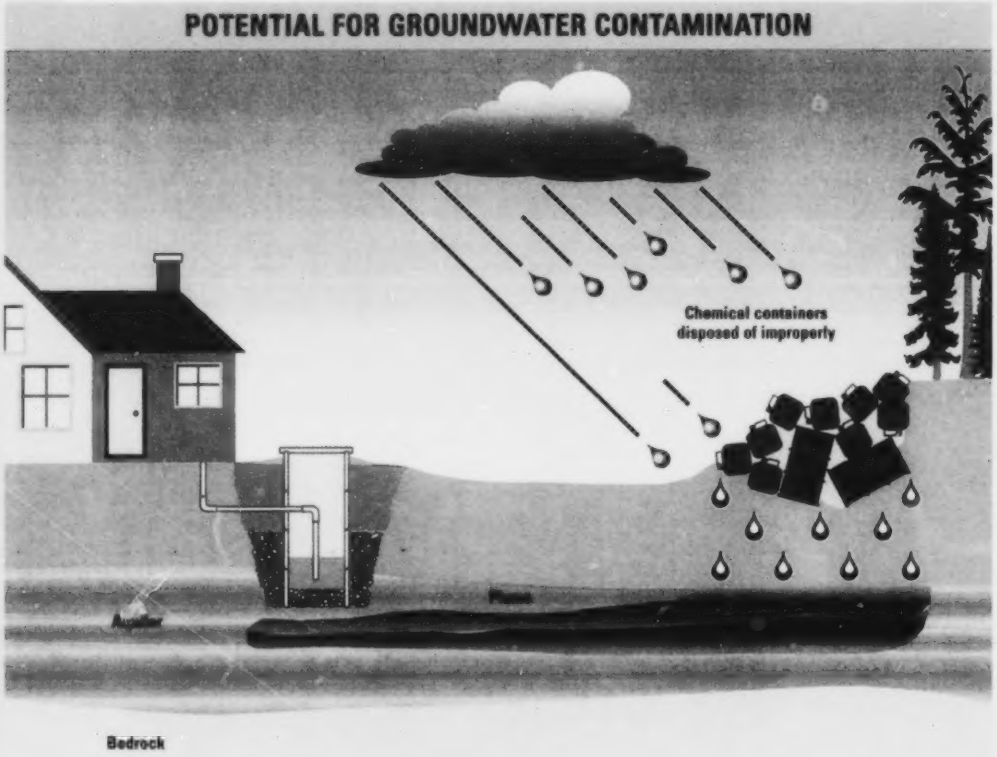
HOW PESTICIDES CAN CONTAMINATE WATER RESOURCES


POTENTIAL FOR GROUNDWATER CONTAMINATION

Pesticides or pesticide breakdown products from improperly stored containers can contaminate groundwater resources.

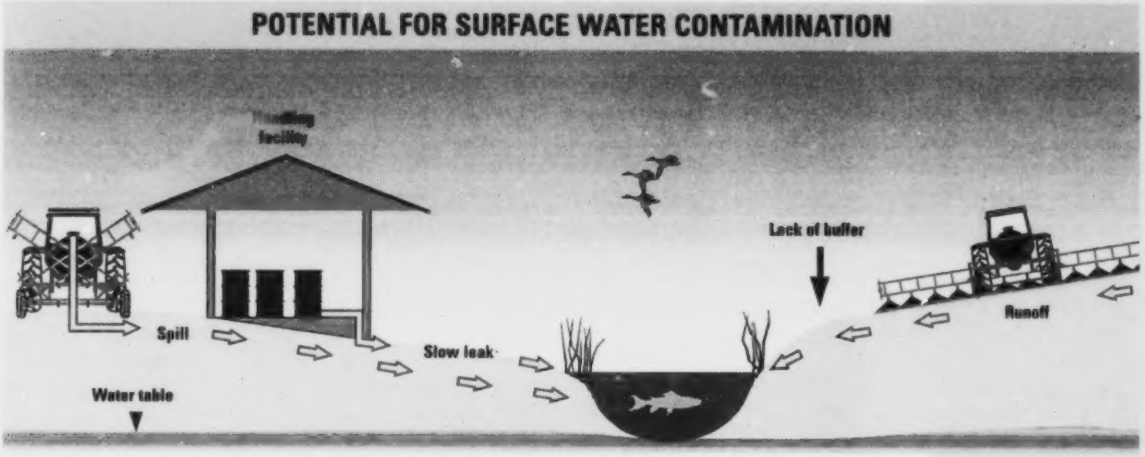
For information on safeguarding wells from contamination, see *Water Wells*, a Best Management Practices book.

Pesticides and their breakdown products can contaminate surface water and groundwater resources by following the pathways of the water cycle or by artificial means. Therefore, care must be taken in areas of porous soil materials, shallow aquifers, poorly protected wells, and concentrated storage or use of pesticides.

Groundwater is recharged by surface water, precipitation, snowmelt, and irrigation waters that percolate through soil and geological materials. The more porous or fractured the materials and the shallower the groundwater resource (aquifer), the higher the rate of recharge.

Ponds and wells, including abandoned ones, not only access aquifers but can also provide direct conduits for infiltrating waters.

INTRODUCTION



POTENTIAL FOR SURFACE WATER CONTAMINATION

Surface waters can be contaminated by pesticides through leakage, spills, and surface runoff.

Not all water infiltrates the soil. About 10% runs off. Rates of runoff increase with slope, lower infiltration rates (e.g., clay soils), and higher volumes of water due to snowmelt, rainfall, and storms.

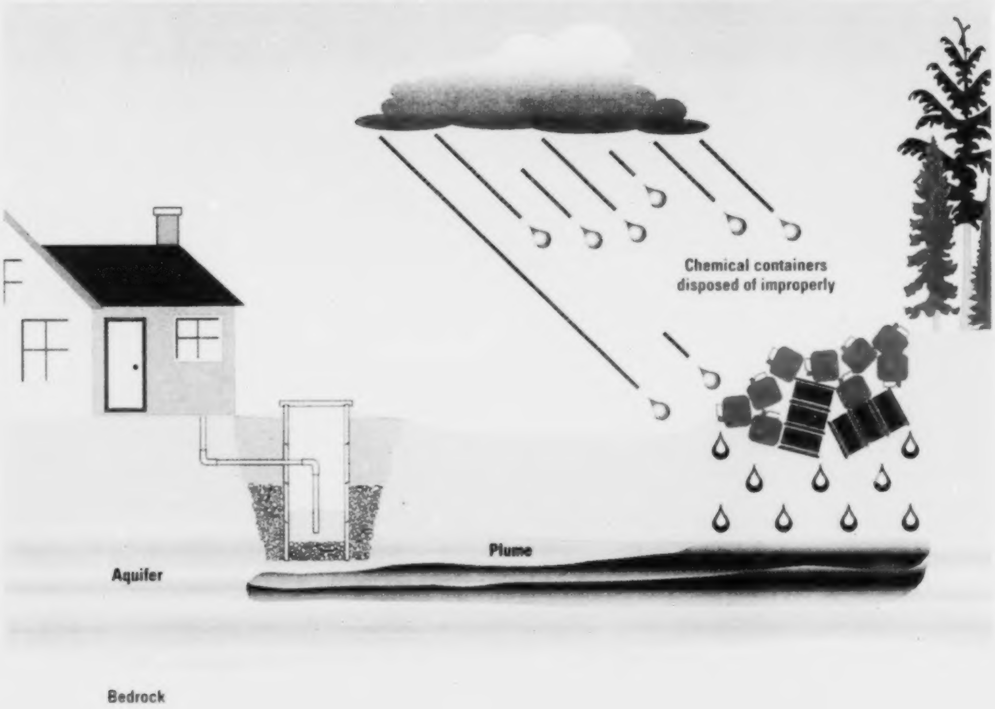
Sometimes, runoff from farmland will reach natural areas such as watercourses, ponds, and wetlands. There is a higher risk to natural areas when the rate of runoff is high, the distance from source is short, and there is no barrier in place to divert the flow. Some pesticides will follow this path of the water cycle: this is particularly a concern in the case of a spill. Some pesticides, like triazines, attach to soil particles and can contaminate natural areas if best management practices are not put in place to control erosion and reduce runoff.

The label instructions reflect all the known properties of the product. Follow the directions carefully to minimize risks to people, livestock, wildlife, and environmental concerns.

There are several production publications that address crop protection and use of pesticides. Many of these are updated annually with the latest recommendations for pesticides and related practices. For some crops (e.g., muck crops, apples), integrated pest management manuals are also available to assist growers in better managing pesticide use. A list of publications is provided on the back cover of this book.

HOW PESTICIDES CAN CONTAMINATE WATER RESOURCES

POTENTIAL FOR GROUNDWATER CONTAMINATION



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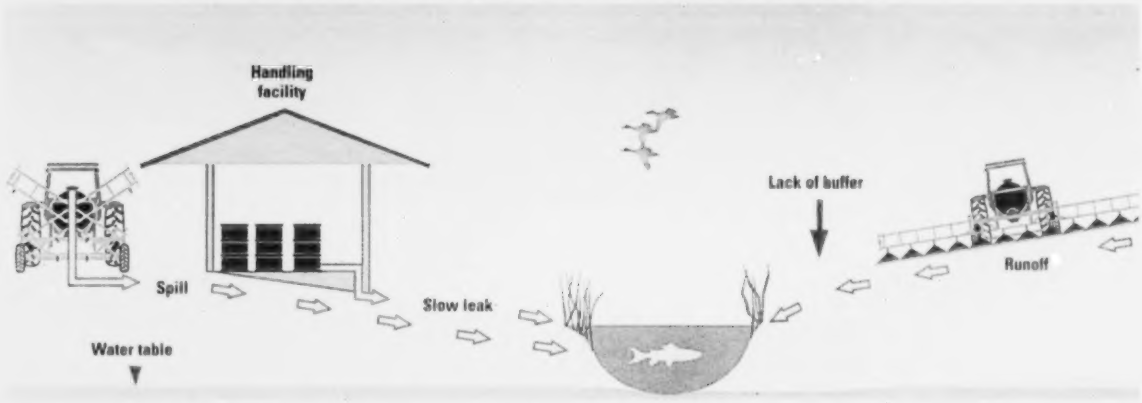

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HAZARDS OF MOST COMMONLY USED PESTICIDES IN ONTARIO

				SOIL AND WATER		WILDLIFE TOXICITY			
PRODUCT NAME	**LABELLED SIGNAL WORD**	**WINTER STORAGE**	**LEACHING**	**ADSORPTION**	**SOLUTION**	**MAMMALIAN TOXICITY**	**BIRDS**	**FISH**	**BEES**
HERBICIDES									
Metolachlor (Dual®)	Warning	B	L	M	L	LT	VLT	MT	NT
Atrazine (Aatrex®)	Caution	B	M	M	M	LT	LT	LT	NT
Glyphosate (Roundup®, Touchdown®)	Warning	B	L	H	H	LT	VLT	VLT	NT
2,4-D amines	Warning	A	M	L	M	MT	MT	VLT	NT
INSECTICIDES									
Azinphos-methyl (Guthion®, Sniper®)	Danger	A	L	M	H	VHT	HT	VHT	HT
Terbufos (Counter®)	Danger	C	L	L	M	ET	HT	MT	MT
Carbaryl (Sevin®)	Warning	A	L	L	M	MT	LT	MT	HT
Carbofuran (Furadan®)	Danger	A	H	M	H	ET	HT	HT	HT
Cypermethrin (Cymbush®)	Warning	A	VL	M	L	MT	VLT	MT	HT

INTRODUCTION

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FUNGICIDES									
Mancozeb (Dithane®, Manzate, Penncozeb®)	Caution	C	L	H	L	LT	LT	LT	NT
Sulfur	Caution	C	M	H	L	LT	VLT	VLT	NT
Myclobutinal (Nova®)	Caution	A	L	L-M	L	LT	LT	MT	NT
NEMATOCIDES									
1,3-dichloropropene (Telone®)	Danger	B	M-H	L	H	MT	MT	HT	NT
Methyl isothiocyanate (Vorlex®)	Danger	B	M-H	L	H	MT	MT	HT	NT

WINTER STORAGE

- A – Do not allow to freeze.
- B – Preferably should not freeze. If frozen, return to original state by allowing product to warm to 10-20°C and agitate thoroughly before use.
- C – Not usually damaged by freezing. Store in a cool, dry place. Emulsifiable concentrate and solution formulations in this group are stable to -18°C. Dry flowable formulations packaged in water-soluble film should not be moved while frozen.

SOIL AND WATER RATINGS

VL – very low
L – low
M – moderate
H – high

MAMMALIAN TOXICITY (ORAL LD$_{50}$ RATE mg/kg)

VHT (extreme toxicity) – 0-10
HT (high toxicity) – 11-100
MT (moderate toxicity) – 101-1000
LT (low toxicity) – 1001-10000
VLT (very low toxicity) – >10000

BIRDS (ACUTE ORAL mg/kg)

VHT – <10
HT – 10-50
MT – 51-500
LT – 501-2000
VLT – >2000

FISH (ppm)

VHT – <0.1
HT – 0.1-1
MT – 2-10
LT – 11-100
VLT – >100

BEES

HT: Kills on contact.
MT: Kills bees if applied over them.
NT: Relatively non toxic. Can be used with few precautions with minimum injury to bees.

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INSECTICIDES									
Azinphos-methyl (Guthion®, Sniper®)	Danger	A	L	M	H	VHT	HT	VHT	HT
Terbufos (Counter®)	Danger	C	L	L	M	ET	HT	MT	MT
Carbaryl (Sevin®)	Warning	A	L	L	M	MT	LT	MT	HT
Carbofuran (Furadan®)	Danger	A	H	M	H	ET	HT	HT	HT
Cypermethrin (Cymbush®)	Warning	A	VL	M	L	MT	VLT	MT	HT

HAZARDS OF MOST COMMONLY USED PESTICIDES IN ONTARIO

				SOIL AND WATER		WILDLIFE TOXICITY			
PRODUCT NAME	**LABELLED SIGNAL WORD**	**WINTER STORAGE**	**LEACHING**	**ADSORPTION**	**SOLUTION**	**MAMMALIAN TOXICITY**	**BIRDS**	**FISH**	**BEES**
FUNGICIDES									
Mancozeb (Dithane®, Manzate, Penncozeb®)	Caution	C	L	H	L	LT	LT	LT	NT
Sulfur	Caution	C	M	H	L	LT	VLT	VLT	NT
Myclobutinal (Nova®)	Caution	A	L	L-M	L	LT	LT	MT	NT
NEMATOCIDES									
1,3-dichloropropene (Telone®)	Danger	B	M-H	L	H	MT	MT	HT	NT
Methyl isothiocyanate (Vorlex®)	Danger	B	M-H	L	H	MT	MT	HT	NT

WINTER STORAGE

A – Do not allow to freeze.

B – Preferably should not freeze. If frozen, return to original state by allowing product to warm to 10-20°C and agitate thoroughly before use.

C – Not usually damaged by freezing. Store in a cool, dry place. Emulsifiable concentrate and solution formulations in this group are stable to -18°C. Dry flowable formulations packaged in water-soluble film should not be moved while frozen.

SOIL AND WATER RATINGS

VL – very low
L – low
M – moderate
H – high

MAMMALIAN TOXICITY (ORAL LD_{50} RATE mg/kg)

VHT (extreme toxicity) – 0-10
HT (high toxicity) – 11-100
MT (moderate toxicity) – 101-1000
LT (low toxicity) – 1001-10000
VLT (very low toxicity) – >10000

BIRDS (ACUTE ORAL mg/kg)

VHT – <10
HT – 10-50
MT – 51-500
LT – 501-2000
VLT – >2000

FISH (ppm)

VHT – <0.1
HT – 0.1-1
MT – 2-10
LT – 11-100
VLT – >100

BEES

HT: Kills on contact.
MT: Kills bees if applied over them.
NT: Relatively non toxic. Can be used with few precautions with minimum injury to bees.

STORAGE

This chapter covers:

- **why storage is necessary**
- **what a storage system should do**
- **how to properly locate your storage**
- **critical components of storage structure types**
- **how to construct a safe pesticide storage**
- **best management practices for storing pesticides, including fire prevention**
- **best management practices for transporting pesticides.**

If you use pesticide products, you should have a proper pesticide storage system. Such a system would include the storage facility and the management practices required to make the system work. There are several worthy reasons for taking good care:

- safety
  - for people – children can be exposed to or ingest lethal amounts of pesticide products
  - for livestock – contamination of livestock facilities and feeds by concentrated amounts of certain pesticides can poison or kill livestock
  - for wildlife – poorly stored products can be accessible to wildlife
- security – pesticide containers could be stolen or vandalized
- fire safety – firefighters are less likely to be exposed if they know where pesticides are stored and can take appropriate precautions to contain runoff
- environmental protection
  - leaks from pesticide containers can infiltrate groundwater – 1 gram of 2,4-D can render an entire aquifer unsuitable as drinking water
  - runoff from spilled containers can contaminate any watercourse in close proximity
  - spilled pesticides such as herbicides can run off into natural areas and destroy living vegetative habitats
- practicality – storing pest control products in one safe place helps to keep inventories organized and readily accessible to certified users.

Strictly speaking, a spill is a discharge into the natural environment, from or out of a structure, vehicle, or other container, that is abnormal in quantity or quality in light of all the circumstances of the discharge.

Pesticides should be stored to protect people, livestock, wildlife, habitat, and water quality.

Leaks from improperly stored pesticides can run off to ponds and other surface waters. Buffer strips help to control agricultural runoff.

STORAGE

PRINCIPLES

Planning an effective pesticide storage system requires careful attention to several performance measures.

MEASURE	RATIONALE
AMOUNT STORED	• how much storage do you need? ○ less is best: fewer types and amounts to be stored translates into fewer risks of spills, leaks, fire exposure, or contamination
LOCATION	• how far from environmental risks can you locate your system and still be practical? ○ the closer pesticides are to water sources and natural areas, the higher the risk ○ shallow aquifers under porous soil materials or bedrock pose high risks for groundwater contamination
SUITABILITY	• does the system suit your needs? ○ systems should be accessible and affordable
CONTAINMENT	• if there is a spill or leak, will it be contained in the storage? ○ special considerations such as secondary containment (e.g., curbs) and materials (e.g., coatings) can prevent leakage to water sources, natural areas, and groundwater
WORKER SAFETY	• is the storage safe for pesticide users? ○ most exposure to pesticides occurs during transportation and filling the sprayer ○ storage areas should have safety and first-aid equipment readily available ○ ventilation is needed to prevent exposure to fumes ○ workers must be trained to handle products and emergencies safely
ANIMAL SAFETY	• are the stored products accessible to pets, livestock, and wildlife? ○ some pesticide products are acutely toxic to animals, so storage areas must be secure and located away from any animals
PROTECTION FROM FIRE	• is the storage facility fireproof? ○ combustion of some pesticide products or accidental mixes of products can produce toxic fumes ○ fire-resistant construction materials and proper storage practices of flammable products help prevent fires
SECURITY	• is the storage accessible to children, thieves, or vandals? ○ some pesticide products can be lethal if ingested ○ vandals can unknowingly or intentionally cause irreparable damage to water sources and natural areas with pesticide products ○ storage areas should be signed correctly, locked, and safe
PRODUCT INTEGRITY	• are products stored in their original containers? ○ children have died by drinking a concentrated pesticide product from pop bottles ○ tank-mixed or diluted products may freeze, causing leakage ○ wet bags lead to spills (e.g., solupaks must be kept dry)

Store as few pesticides as possible. Store products of different classes in separate areas of the storage facility.

Pesticide storages should be located to minimize risk of contamination of groundwater, surface water, natural habitats, livestock feeds, and human activity.

Choosing a location for your pesticide storage should include consideration of safety and environmental protection together with practicality.

Storages should be locked and signed to prevent access.

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STORAGE

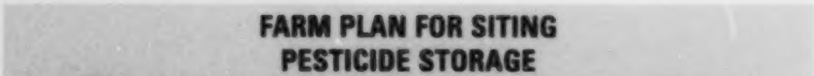
SITE SELECTION

Select a site for pesticide storage that is practical and safe for people and the environment. The two questions to be dealt with are:

- how do you place your chemical storage so that the chance of human contact – especially accidental or unauthorized – is reduced or eliminated?
- what is the best location for your storage to minimize any environmental impact of a leak or serious spill?

Factors to consider when choosing a storage site:

- human safety
  - pesticides should be stored and secured as far away as practical from food and water supplies – 60 metres (200 ft.) minimum from residential dwellings
- surface water and groundwater contamination
  - pesticides should be stored at a minimum distance of 90 metres (300 ft.) from surface water and wells
  - sites that slope towards watercourses pose a greater risk of contamination
- livestock feeds
  - livestock feeds are not to be stored in the same location as pesticides, to avoid risk of contamination of feed
- wildlife habitat
  - pesticide spills can destroy habitat areas, so locate storage at least 90 metres (300 ft.) away from wetlands, woodlands, and watercourses
- access
  - distance to hydro, water, other needed utilities
  - ability to access storage with machinery if required by fire department and other emergency vehicles
- potential for future expansion
  - increased size of storage or location of handling facility beside it

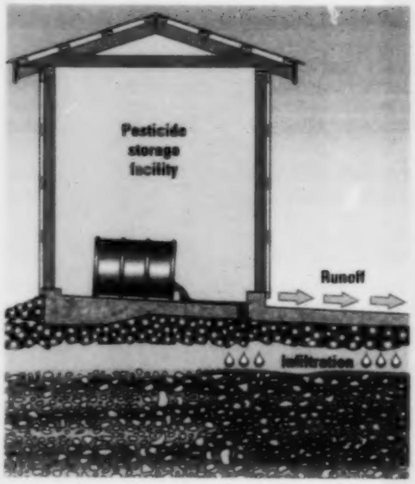

FARM PLAN FOR SITING PESTICIDE STORAGE
Runoff
New storage/ mixing/ loading site
Stream
Livestock barn
90 m (300 ft.)
5 m (15 ft.) Buffer
Old storage area
90 m (300 ft.)
To cropland
150 m (500 ft.)
Well
Winter prevailing wind
House
Farm shop
Summer prevailing wind

Integrating minimum separation distances is the most important consideration when selecting a site for your pesticide storage.

STORAGE

- soil conditions
  - clayey soils have higher potential for runoff, but a lower risk of groundwater contamination
  - the risk is higher on soils prone to groundwater contamination (shallow to bedrock, gravelly, sandy soils and all sites with high water table) – if possible, try to select a site on soils with a lower risk of contamination.

Compared to clay soils, sandy soils have large spaces between the soil particles. Water may move quickly through these pores, carrying pesticides to groundwater. The following section can help you decide on leaching potential.



Improperly stored pesticide containers are at risk of spills or leaks. Spilled pesticides in areas with high runoff rates and close proximity to natural areas can cause serious contamination. Pesticide leaks into permeable materials with shallow aquifers (e.g., fractured bedrock sites) can contaminate groundwater.

POTENTIAL FOR PESTICIDES TO BE TRANSPORTED TO GROUNDWATER AND SURFACE WATER

You can use a soil map to help estimate the risk of pesticide contamination by determining the risk of transport of pesticide products.

There are five key site features that affect water contamination risk.

Soil texture	Texture is the relative coarseness or fineness of soils. Clayey soils are more prone to runoff as water infiltrates and percolates through them slowly.
Soil depth	Sites with soils shallow to bedrock or to groundwater pose a higher risk of runoff and groundwater contamination. Soils with a naturally occurring high water table are classed as "Very Poor", "Poor" or "Imperfect" in soil survey reports and map legends.
Perviousness	This is the relative speed at which water moves through soil. The most pervious are sandy and gravelly soils, because they are porous and have fewer charged soil particles (clay and organic matter). The more porous soils allow water to move more quickly through them to groundwater, allowing minimal opportunity for treatment or breakdown of contaminants.
Slope class	Slope is the elevation difference over a specified distance that is measured as a percent: 0% slope means level, whereas with a 5% slope, runoff during snowmelt and storm events would be clearly evident.
Proximity	Distances to watercourses, wetlands, ponds, and lakes contribute to the risk of surface water contamination from pesticide runoff.

Soil maps and reports can be very useful sources of information when selecting suitable sites for pesticide storage and handling facilities.

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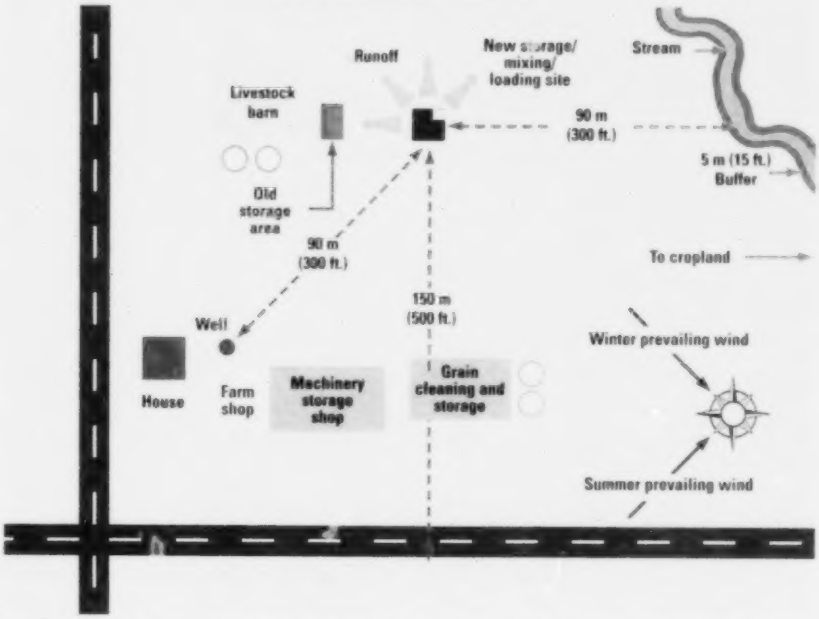
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House
Farm shop
Machinery storage shop
Grain cleaning and storage
Summer prevailing wind

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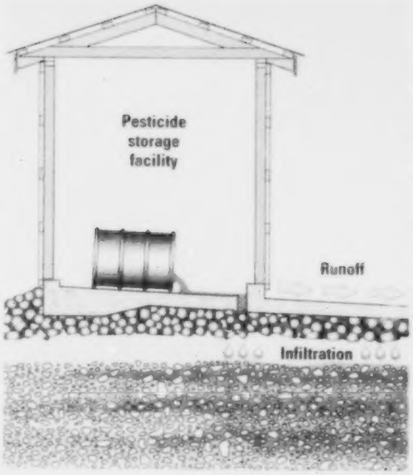

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STORAGE

Ratings for groundwater contamination potential

1 = high
2 = moderate
3 = low
4 = very low

GROUNDWATER CONTAMINATION POTENTIAL

SOIL TEXTURE (NATURAL DRAINAGE)	DEPTH TO GROUNDWATER <1 m (3 ft.)	1-5 m (3-15 ft.)	5.1-15 m (16-50 ft.)	>15 m (50 ft.)
BEDROCK WITHIN 1 m	1	1	1	1
MUCK (FAST-MODERATE)	1	—	—	—
SANDS* (FAST)	1	1	1	2
LOAMS* (MODERATE)	1	1	2	3
CLAY LOAMS* (SLOW)	1	2	3	4
CLAYS* (VERY SLOW)	1	3	4	4

RECOMMENDED MINIMUM SEPARATION DISTANCES BETWEEN STORAGE LOCATION AND WELLS

RATING, CONTAMINATION POTENTIAL	MINIMUM SEPARATION DISTANCE	
	DRILLED WELLS	DUG OR BORED WELLS
1	>90 m (300 ft.)	>90 m (300 ft.)
2	23.1-90 m (76-300 ft.)	45.1-90 m (151-300 ft.)
3	15.1-23 m (51-75 ft.)	30.1-45 m (101-150 ft.)
4	15 m (50 ft.)**	>30 m (100 ft.)**

To judge groundwater contamination potential, take the rating from the first table and determine recommended separation distance from the second table.

For example, with a depth to groundwater of 5.1-15 metres (16-50 ft.) on a clay loam soil, the potential is "3". This means your distance to a drilled well should be in the range of 15.1-23 metres (51-75 ft.). If the soil type is sand, with a similar depth to groundwater, the potential is "1", or high. Here, the distance to your drilled well should be greater than 90 metres (300 ft.)

---

* **Sands** – all sands and loamy sands (e.g., loamy fine sand)
Loams – sandy loam, silt loam, and loam
Clay Loams – silty clay loam, sandy clay loam, and clay loam
Clays – silty clay, sandy clay, heavy clay, and clay

****Minimum distance required to be consistent with water well regulations under the Ontario Water Resources Act (Reg. 903).**

STORAGE

SURFACE WATER CONTAMINATION POTENTIAL

SOIL TEXTURE (NATURAL DRAINAGE)	TOPOGRAPHY (LAND SLOPE)		
	LEVEL <2%	SLOPING 2-5%	HILLY >5%
MUCK (FAST-MODERATE)	3	—	—
SANDS* (FAST)	4	4	3
LOAMS* (MODERATE)	3	3	2
CLAY LOAMS* (SLOW)	2	2	1
CLAYS* (VERY SLOW)	1	1	1

RECOMMENDED MINIMUM SEPARATION DISTANCE BETWEEN STORAGE LOCATION AND SURFACE WATER SOURCES

SURFACE WATER CONTAMINATION POTENTIAL	MINIMUM SEPARATION DISTANCE
1	>150 m (>500 ft.)
2	60.1-150 m (201-500 ft.)
3	30.1-60 m (101-200 ft.)
4	30 m (100 ft.)

Ratings for surface water contamination potential

1 = high

2 = moderate

3 = low

4 = very low

Slope of land in direction of the surface water source and type of soil determine surface water contamination potential. These tables can assist you in judging this potential.

To judge surface water contamination potential, take rating from the upper table and determine recommended separation distance from the lower table.

For example, the recommended separation distance for a sandy loam soil with 2-5% slope is 30.1-60 metres (101-200 ft.) between the pesticide storage and the surface water source.

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Here are the performance requirements for a pesticide storage. In some jurisdictions, these items are legal requirements.

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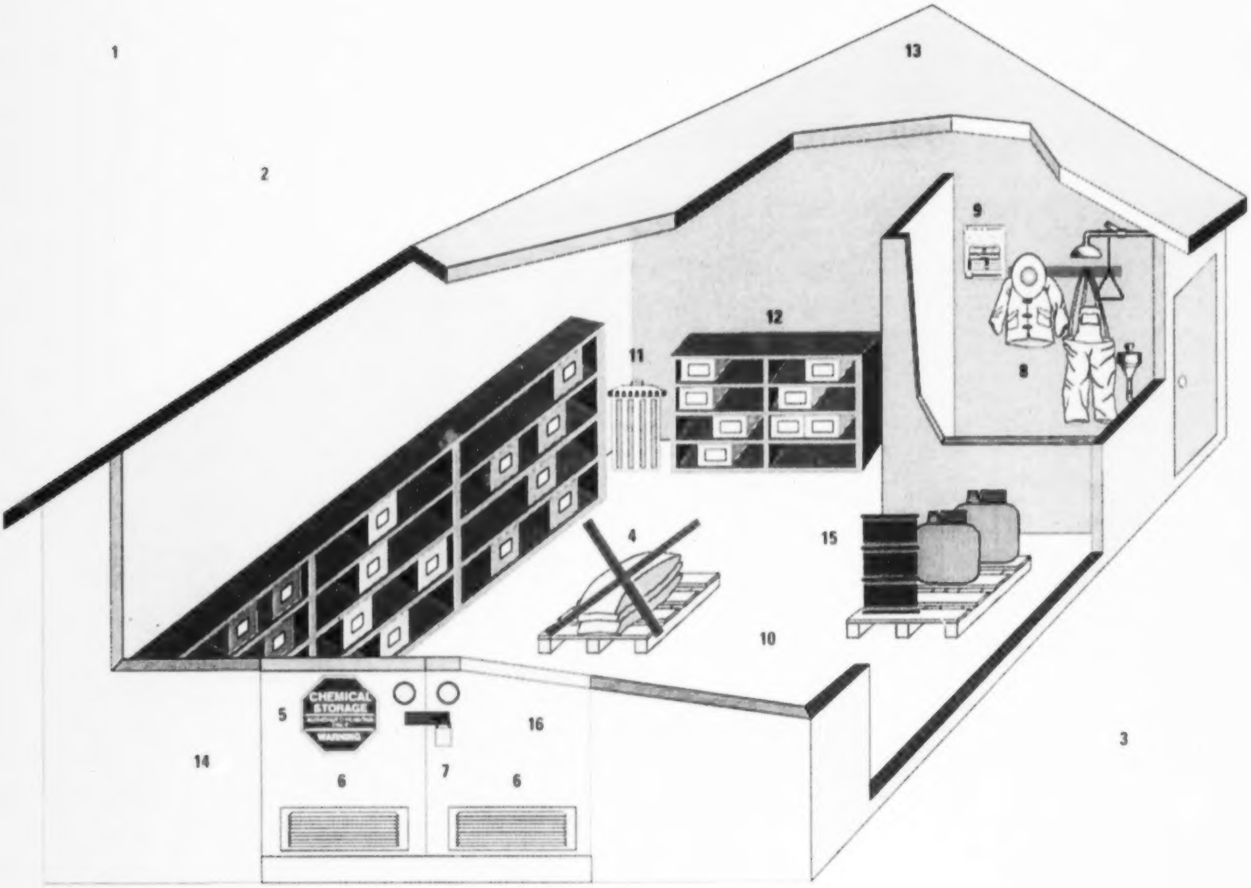
1
13
2
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10
CHEMICAL STORAGE
WARNING
5
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STORAGE

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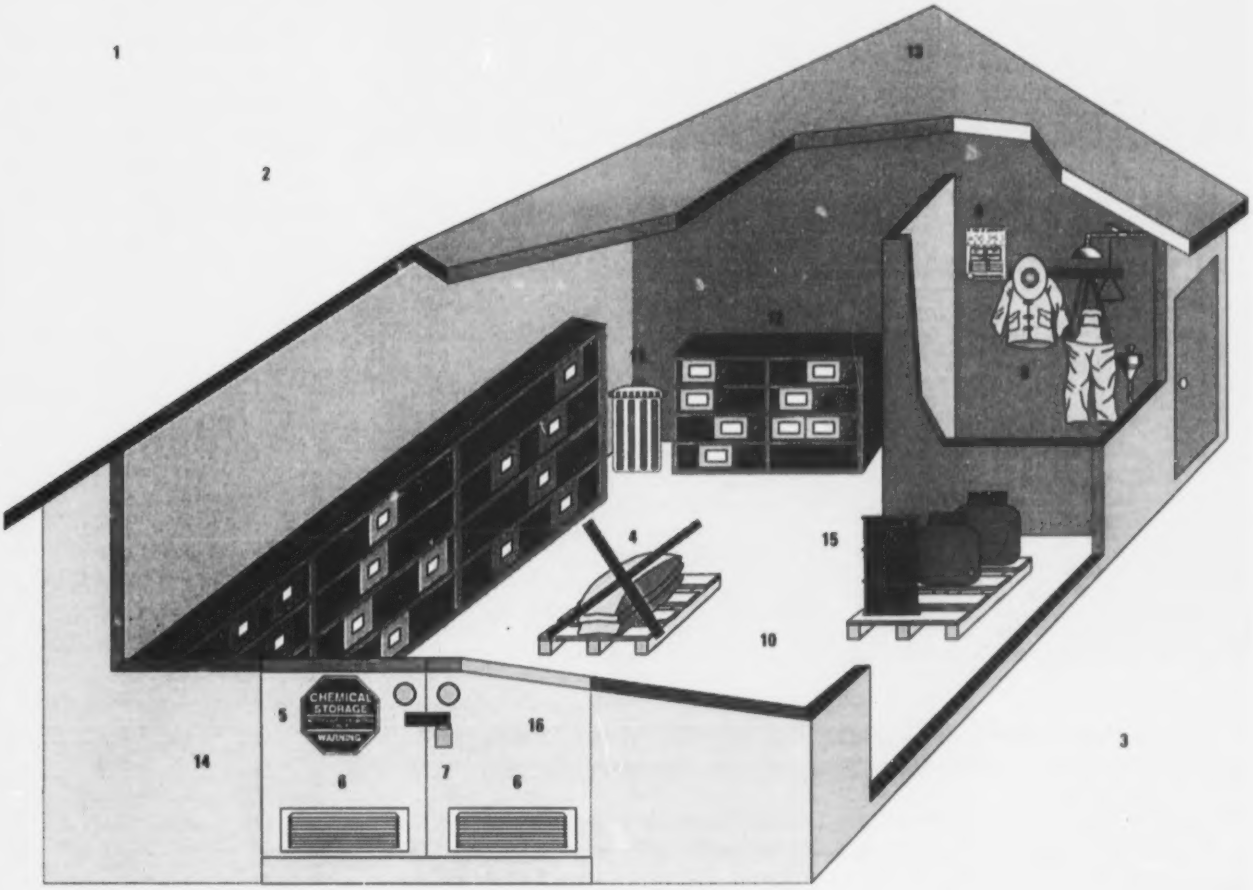
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CHEMICAL STORAGE
WARNING
5
16
3
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6
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6

STORAGE

CHECKLIST

☑ 1. **FOOD AND LIVESTOCK KEPT AWAY** – pesticides must be stored in such a manner that the pesticide will not come into contact with food or drink intended for human or animal consumption.

☑ 2. **PRODUCTS STORED SAFELY AND SECURELY** – pesticide products must be stored in such a way that the health and safety of any person are not impaired.

☑ 3. **ENVIRONMENTAL PROTECTION** – stored products must not contaminate the environment or other pesticides. Site storage away from surface water and natural areas.

☑ 4. **ONLY PESTICIDES ALLOWED IN STORAGE** – pesticide storages must only be used for the storage of pesticides.

☑ 5. **SIGN ON DOORS** – a Chemical Storage Warning sign must be permanently affixed to or adjacent to the outside of each entrance leading into the storage area.

☑ 6. **VENTILATION** – the storage should be ventilated to the outside atmosphere. Either natural ventilation or mechanical ventilation may be used to exhaust fumes from the storage, and improve air quality.

☑ 7. **LOCKED DOORS** – the door must be locked to prevent theft and unauthorized entry.

☑ 8. **PROTECTIVE CLOTHING AND RESPIRATORY EQUIPMENT AREA** – these must be readily available and stored so that they do not become contaminated, e.g., in an adjacent room or a nearby building. Protective clothing and respiratory equipment includes: chemical-resistant gloves and apron, long-sleeved shirt and pants or coveralls, boots, waterproof hat, goggles, face shields, and respirators.

☑ 9. **CONTINGENCY PLAN** – emergency telephone numbers must be displayed in a permanent place close to a telephone. Numbers should include hospital, ambulance, physician, poison control centre, spills action centre, fire department, police, and the Ministry of the Environment.

☑ 10. **FLOOR IS IMPERMEABLE, CURBED, AND SEALED** – the storage area should have a floor that does not allow material to leak into or through it. It should NOT have floor drains of any sort. Many operators use sealed concrete. In order to contain any spills, there should also be a curb around the entire floor perimeter of the storage facility. The curb should be adequate to contain 110% of the largest containment vessel or 10% of the aggregate volume of all containers, whichever is the larger of the two. A curb height of 50-100 mm (2-4 in.) is usually adequate.

☑ 11. **ABSORBENT MATERIALS AVAILABLE** – materials such as sawdust, soil, and kitty litter should be available for a spill cleanup.

☑ 12. **SEPARATED BY PESTICIDE TYPE** – the area should be set up so that herbicides are stored separately from insecticides and fungicides.

☑ 13. **STRUCTURE AND PESTICIDES KEPT DRY** – the storage should be kept dry and secure to protect the stored chemicals. Moisture can cause some packaging material to rupture and split, or labels to become difficult to read.

☑ 14. **FIREWALLS** – if the pesticide storage facility is constructed within another building, the interior separation walls of the pesticide storage should have a fire resistance rating of not less than one hour. The primary entrance to the storage area should be from the outside.

☑ 15. **PRODUCTS KEPT OFF FLOOR USING PALLETS** – keep containers off the floor with pallets to maximize the space available for containment of a spill.

☑ 16. **DOOR SIZES ADEQUATE** – make sure you consider the size of the doors so that bulk pesticides may be stored.

Storage size requirements can be reduced if you store only what is needed.

The storage and handling requirements will change with each farm operation.

The **size** of the storage building will be determined by:

- ▶ type and quantity of pesticides stored
- ▶ size of containers typically used
- ▶ formulation – liquid or dry

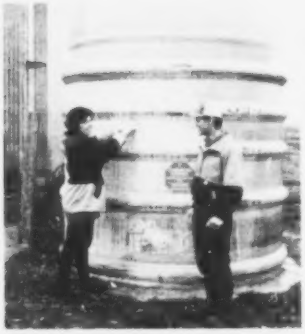
It is uncertain what form future pesticides will take. The current trend is toward more concentrated forms of materials. Highly concentrated formulations should require less – possibly unheated – space. The use of large containers, such as drums or bulk storage, may have to be considered.

Storage cabinets can be used for storing small volumes. Whether they're constructed, prefabricated or modified cabinets (e.g., freezers), they must meet many of the design criteria of the larger free-standing storages.

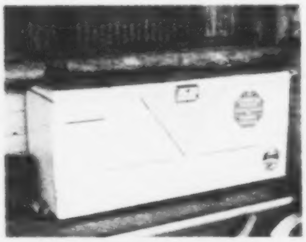
Free-standing storages are either:

- ▶ *farm-built* – suggestions follow on how to approach the construction of your own facility; pay particular attention to floor characteristics
- ▶ *prefabricated* – in order to save time, growers may choose a ready-made unit designed to meet pesticide storage requirements

Storage within, or attached to, another building is also an option. A few guidelines are provided on the following pages.



One end of a used fibreglass fuel tank was attached to a seamless concrete floor (with 150 mm [6 in.] curb) to create this unique pesticide storage. Total material cost was $185.



Use only freezers that you do not intend to use for food.

COMPARING STORAGE TYPES

TYPE	PROS	CONS
STORAGE CABINET	• movable • may be low cost	• limited size
PREFABRICATED	• convenient • generally competitive costs • designed for this purpose	• not always available in all regions
FARM-BUILT	• build to size needed • low cost if built by farmer	• difficult to construct quality floor, i.e., sealed
STORAGE WITHIN BUILDING	• makes use of some of the existing walls • may be less cost	• risk to other stored items • fire hazard potential • removes that portion of building from original use

STORAGE

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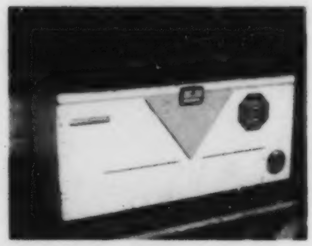

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STORAGE

STORAGE CABINET

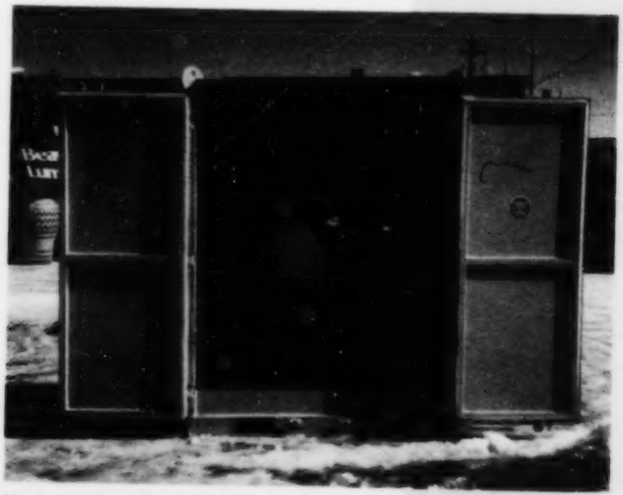
HORIZONTAL

- old freezers, equipped with locks and signs, serve as a good storage
- refrigerant must be removed by a licensed contractor
- ventilation is recommended at a specification of 1 ft.^{2} of ventilation intake/exit area to each 100 ft.^{3} of storage
  - two screened 4 in. PVC pipes, vented to the outside, at either end of the cabinet and at about 1 foot off the ground will provide enough ventilation for the average-sized freezer, 2 x 5 x 2.5 ft.
- to prevent freezing, use two low-wattage light bulbs, e.g., 40 watt, in parallel circuits (so there's less chance that both will fail at once)

Remember to place locks and signs on all storage facilities.

VERTICAL

- a closet-sized (2 x 3 x 7 ft.) cabinet will be adequate for some operations
- install a vent pipe(s) to the outside to prevent a buildup of vapours
- should have an impervious floor with a curb to contain spills
- should be signed and locked
- two single low-wattage bulbs (e.g., 40 watt) should prevent freezing



Vertical cabinets can make suitable storages, provided they are vented, locked, and will contain leaks.

STORAGE

It took $1,040 in materials and $400 in labour to construct this pesticide storage, which uses a septic tank as a leakproof base.

FARM-BUILT FREE-STANDING

PROS	CONS
• can be built to meet your specific requirements, e.g., floor area, layout	• may be difficult to build a proper floor on-site
• usually less costly if you build yourself	• quality of construction of components, e.g., concrete floor may be inferior to precast slabs
• flexibility in choice of materials, e.g., steel floor vs. concrete floor	• portability – usually difficult to move to another location
	• requires time to plan and construct on site

This farm-built free-standing pesticide storage was constructed according to recommended design criteria. Cost: $4,000.

A farm-built storage can be a good choice. Before starting on this project, contact your local municipality regarding local design criteria and a building permit. Here are some key considerations:

- ▸ layouts – shelving, insulated cabinet, anteroom (worker safety area)
- ▸ floor area requirements
- ▸ floor types and design details – impervious concrete/steel, including curbs and spill containment
- ▸ wall types and construction – i.e., stud wall/steel-clad, all steel, or concrete block
- ▸ insulation vs. non-insulation – heating methods if insulated, i.e., some chemicals must be kept from freezing
- ▸ ventilation criteria – natural ventilation or mechanical ventilation
- ▸ a concrete ramp can be built with a finished elevation equal to the top of the curb.

STORAGE

It took $1,040 in materials and $400 in labour to construct this pesticide storage, which uses a septic tank as a leakproof base.

FARM-BUILT FREE-STANDING

PROS	CONS
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STORAGE

LAYOUT AND STORAGE SPACE

- storage needs mostly depend on the size and number of pesticide storage containers
- keep different pesticide products separate, e.g., insecticides and herbicides
- shelves should not be >150 cm (60 in.) above the floor
- to prevent contamination, shelves should not be less than curb height
- shelf width should not exceed 45 cm (18 in.) and should have a 5 cm (2 in.) lip around the perimeter to contain spills
- aisle width should be a minimum of 60 cm (24 in.)
- total design should account for storage of empty containers, water sinks, safety showers, and anteroom for storage of personal protection equipment

FLOORS

o.c. = on-centre

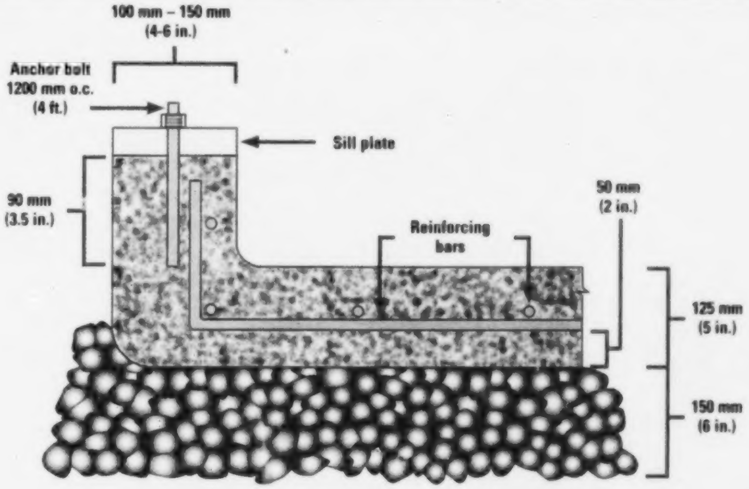
MPa = megapascals

- subbase should be well-drained and compacted
- floors must be impervious, with no drains, a 5-10 cm (2-4 in.) curb, easily cleaned and skid-proof
- materials can be steel or concrete
- concrete floors should be 10 cm (4 in.) minimum thickness
- concrete floors should have reinforcing rods 600 mm (24 in.) o.c. in both directions and bent up into the concrete curb
- concrete floors should have 25 MPa (3,500 psi) compressive strength, 5% air entrainment, and low water content
- steel floors should be heavy-gauge metal with epoxy coating

WALLS

- wall structure can be constructed of wood or steel studs, posts, cement blocks, or poured concrete
- wall cladding may be galvanized steel, painted steel, board, or brick
- keep number of windows to a minimum to restrict access; place steel bars over windows to eliminate entry

STORAGE FLOOR



The pesticide storage floor should be at least 10 cm (4 in.) thick with a 5-10 cm (2-4 in.) curb.

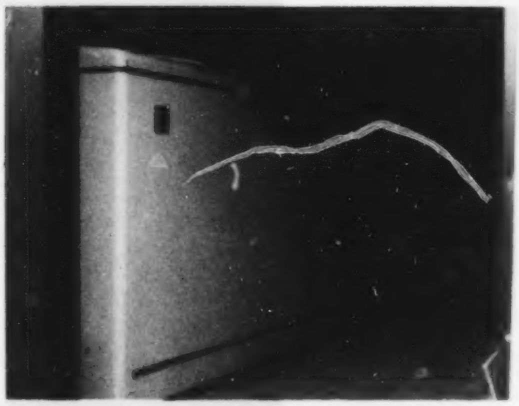
STORAGE

HEATING AND INSULATION

- where climate and pesticide type necessitate, add insulation and/or heating
- the entire storage may be insulated and heated, or an insulated cabinet may be used to store pesticides susceptible to freezing – lightbulbs will provide heat for the cabinet
- storage temperature ranges from 4-32°C (40-90°F)
- insulate with a minimum of R-20 insulation for walls and R-30 for ceiling
- use electric or hot water heat
    - AVOID FLAMES OF ANY SORT – they could ignite volatile and flammable gases from leaking pesticide containers
    - heaters should be controlled by a thermostat
    - use only armoured cabling and new equipment intended for dust-laden environments

PROTECTION FROM FREEZING

- if storage area is uninsulated, provision must be made to protect susceptible chemicals from freezing
- some chemicals will crystallize or become deactivated, making them unfit for spraying
- further, freezing causes water-based liquids to expand their volume by 10%, causing ruptures of containers
- a well-insulated cabinet can be heated with two low-wattage light bulbs, provided stored items do not contact bulbs



A well-insulated frost-free cabinet located inside a pesticide storage can be heated with two low-wattage light bulbs.

STORAGE

NATURAL VENTILATION

- ventilation is required to remove fumes, as well as excess heat and humidity
- requires inlet and exhaust system
- for unheated or uninsulated storages, provide at least .55 m^2 (6 ft.^{2}) (total inlet and exhaust area) per 9 m^2 (100 ft.^{2}) of building floor area
- a typical natural ventilation system could be:
    - sidewall soffit air intakes, 10 cm (4 in.) x building length (both sides): gable-end soffit intakes, 10 cm (4 in.) x building width (both ends)
    - screened windows and openings in doors can also be used for extra ventilation in hot weather (openings should be secured with steel bars)
    - all air intakes should be bird, bee and rodent proofed by placing a wire screening over the intake and exhaust openings
    - hinged baffle boards can be used to reduce ventilation during cold weather

MECHANICAL VENTILATION

- if heated and insulated, the goal should be ¼ to ½ air changes per minute
    - a 20-25 cm (8-10 in.) diameter exhaust fan will normally do the job
- for a 3 x 3 m (10 x 10 ft.) building – the inlet size should be 225-450 cm^2 (35-70 in.^{2}) to attain an inlet velocity of 250 m/min. (800 ft/min.) for the ¼ and ½ air changes per minute respectively
- ideally the outside air would enter building through a narrow slot along one side of building with the fan on the other side
- install a switching system so that the fan can be operated manually prior to entry
- fan should be operated by a timer, thereby removing stale air on a regular basis

CONSTRUCTION

The steps required to build your own storage are described in this section. Remember, the local building inspector must be contacted first regarding municipal requirements and a building permit.

FLOOR

There are three options for constructing pesticide storage floors:

- reinforced concrete floor – done on-site
- reinforced concrete floor – prefabricated
- steel floor.

REINFORCED CONCRETE FLOOR, DONE ON-SITE

PROS	CONS
• floor can be done on-site by farmer or contractor	• must be properly designed and constructed or severe cracking will occur
• concrete floor can be formed to one's desires, e.g., lip height, dimensions	• not portable if concrete poured in place
	• if floor is not adequately sealed, chemicals can penetrate floor and contaminate it
	• susceptible to frost/freezing action below the slab

REINFORCED CONCRETE FLOOR – PREFABRICATED

PROS	CONS
• often higher quality than concrete floors poured on-site	• limited to availability of features, e.g., dimensions, lip height
• can be portable	• prefabricated floors not available in all regions

STEEL FLOOR

PROS	CONS
• usually built by steel fabricator to farmer's specifications; thus, no floor construction on farm	• steel fabricators may not be readily available
• chemicals do not penetrate steel floor	• storage must be designed and constructed to allow for installation of the one-piece steel floor
• not susceptible to frost action below floor	• susceptible to corrosion – surface should be protected with an epoxy coating
• can easily be removed from storage and/or be replaced	

STORAGE

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STORAGE

HOW TO CONSTRUCT A REINFORCED CONCRETE FLOOR

After deciding on the location and size of the building, begin by removing the topsoil and all organic debris.

1. Prepare a base with 150 mm (6 in.) of compacted 2 cm ($\frac{3}{4}$ in.) crushed stone on which to build the floating concrete slab.

Step 1 Prepare base.

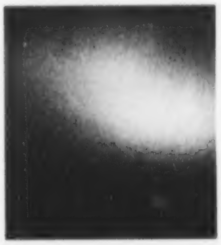
2. Build forms for the cement that will give a continuous 5-10 cm (2-4 in.) curb around the perimeter of the slab, including doors and adjoining rooms. If possible, place curb as part of a continuous pour with the base, thereby eliminating the need for a joint between the floor and the curb. Anchor bolts should be set in the curb to secure the bottom plate to the cement.

Step 2 Build forms.

3. Pour the cement to a depth of about 5 cm (2 in.), then add #10 ($\frac{1}{2}$ in.) reinforcing rods @ 60 cm (24 in.) o.c. in both directions and bend up into the concrete curb. Pour the rest of the cement floor to a total depth of 125 mm (5 in.), and fill the curb forms. Use 25 MPa (3500 psi) concrete with 5% air entrainment. Use a float to finish the cement surface to minimize coarse surface texture.

Step 3 Use float to finish poured floor.

4. Sealing the floor is recommended. (See next page.)



Step 4 Seal the floor with approved concrete-sealer product.

PROTECTIVE COATINGS FOR FLOORS (CONCRETE SEALING PRODUCTS)

PRODUCT	FORM	APPLICATION
BOILED LINSEED OIL AND MINERAL SPIRITS	• 50% liquid mixture	• two applications necessary • variable performance • requires reapplication every one to three years
EPOXY	• two-package system of a resin and a curing agent ◦ some are solids; others are solution coatings	• follow manufacturer's directions for application procedures, proper temperatures, and duration of coating
URETHANE	• coatings that cure by reacting with moisture in the air ◦ require dry conditions to avoid cracking	• careful surface preparation is required • recoating is difficult when sanded • multiple coats necessary to get even seal
POLYESTER/ VINYLESTER	• two- or three-part systems with resin, catalyst, and promoter • range of materials from solids to liquids	• sprayed, brushed or rolled on • apply in five coats to properly coat floor
POLYUREAS	• two-part compounds (see urethane)	• hot mix gun, where materials mix under pressure at nozzle – dry in 15 seconds • multiple layers needed to get 15-45 mil finish
VINYLS	• highly viscous resins	• sprayed onto dry surfaces • fast drying (30 min.) • multiple coats required
CHLOROSULFONATED POLYETHYLENE	• Hypalon	• requires fill coat of grout or mortar plus a primer • four 2-mil coats are required of product
HYDRAULIC CEMENTS	• dry powder mix of cement, sand, and catalyst	• applied as slurry • forms crystalline growth that fills cracks and voids • seals concrete from liquids

STORAGE

PROTECTIVE COATINGS FOR FLOORS (CONCRETE SEALING PRODUCTS)

PRODUCT	FORM	APPLICATION
BOILED LINSEED OIL AND MINERAL SPIRITS	• 50% liquid mixture	• two applications necessary • variable performance • requires reapplication every one to three years
EPOXY	• two-package system of a resin and a curing agent ◦ some are solids; others are solution coatings	• follow manufacturer's directions for application procedures, proper temperatures, and duration of coating
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STORAGE

WALLS AND ROOF CONSTRUCTION CHECKLIST

WALLS

☑ Base plate needs to be secured to poured floor curb with anchor bolts.

☑ Place 12 x 150 mm ($^{1}/_{2}$ x 6 in.) bolt every 1200 mm (4 ft.) o.c.
▶ follow local building codes for stud wall construction.

☑ 38 x 89 mm (2 x 4 in.) for studs at 40-60 cm (16-24 in.) o.c. are recommended.

☑ Walls don't have to be insulated, but check pesticide labels for freezing risks.

☑ For metal-clad buildings, use 28-gauge corrugated steel.

☑ No interior sheathing required except for walls adjacent to anteroom.

☑ Windows provide natural light in storage area
▶ secure storage by placing steel bars over windows.

☑ Install a large entry door, i.e., double door, to allow entry with forklift if necessary.

ROOF

☑ Follow local building code to ensure proper structural adequacy for live and dead roof loads.

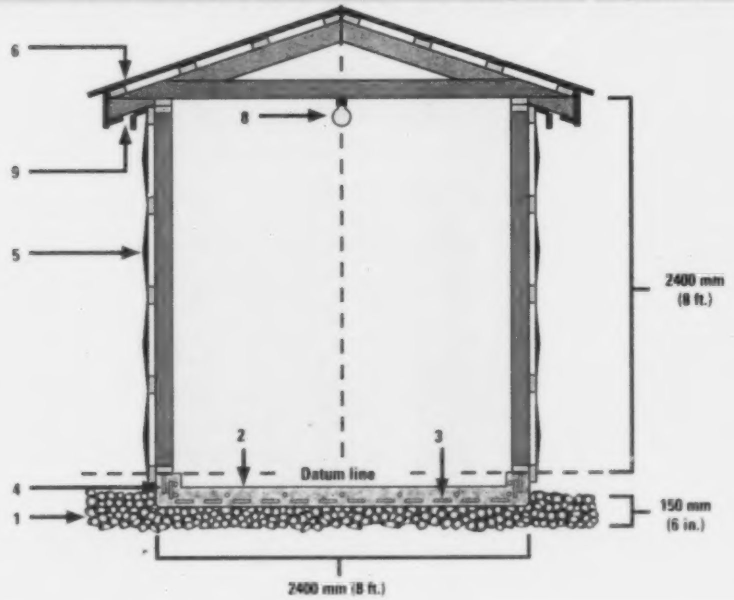
☑ For steel-clad (28-gauge corrugated), use simple rafters or roof truss, with nailing girts.

☑ For asphalt-shingled roof, use light-coloured asphalt shingles nailed to 12 mm ($^{1}/_{2}$ in.) exterior-sheathing plywood.

The base plate needs to be secured to the poured floor curb with anchor bolts.

STORAGE

PLAN FOR FARM-BUILT FREE-STANDING PESTICIDE STORAGE – CROSS-SECTIONAL VIEW



STRUCTURAL FEATURES

1. **BASE** – remove topsoil and prepare base with 150 mm (6 in.) depth compacted granular fill (Granular A).
2. **FLOOR** – floating concrete slab 125 mm (5 in.) thick and curb 90 mm (3½ in.) high formed in one placement. Use 25 MPa (3500 psi) concrete with 5% air entrainment. Curb height is continuous around perimeter of slab (includes doorways and common walls of anteroom).
3. **REINFORCING RODS** – #10 (½ in.) diameter at 600 mm (24 in.) o.c. both directions and bent up into concrete curb.
4. **ANCHOR BOLTS** – 12 x 150 mm (½ x 6 in.) at 1,200 mm (4 ft.) o.c. to secure base plate.
5. **WALLS** – non-insulated stud wall construction (check local building codes). Also, 28-gauge corrugated steel cladding applied vertically on the outside walls. No interior sheathing required except for the common walls between anteroom and storage area (see 12).
6. **ROOF** – check local building codes for local live loads and dead loads to assure structural adequacy of rafters/trusses at a given spacing.

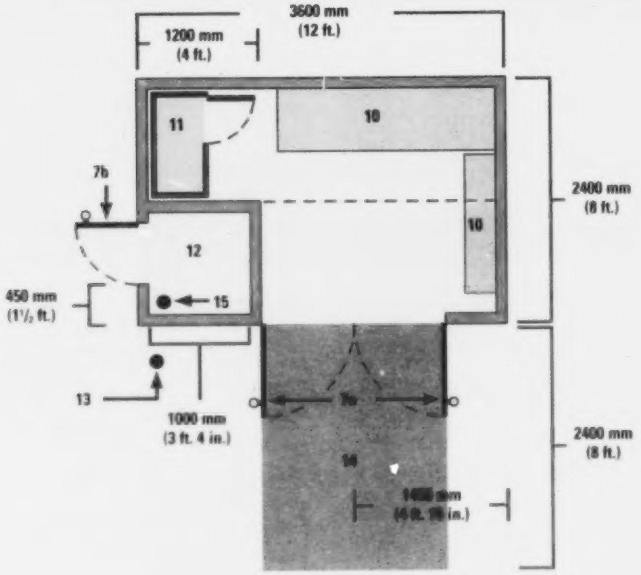
   Roof Types – simple rafter or roof truss with nailing girts and 28-gauge corrugated steel cladding

   – asphalt shingles nailed to 12 mm (½ in.) D.F. exterior sheathing plywood

   NB: light-coloured roofing preferred to reduce heat buildup.
7. **DOORS** – 7(a) 2-900 x 2,000 mm (36 x 80 in.) and 7(b) 600 x 2,000 mm (24 x 80 in.) outward opening exterior-type galvanized steel doors, or wood doors with exterior metal cladding attached for improved resistance against vandalism, rodent/pest damage, and weathering.
8. **LIGHTING** – light fixtures (pigtail type) with 60 watt bulb mounted onto bottom chord of roof truss or rafter. One bulb per room.

STORAGE

PLAN FOR FARM-BUILT FREE-STANDING PESTICIDE STORAGE – AERIAL VIEW



9. **VENTILATION** – sidewall soffit air intakes, both sides, 100 mm (4 in.) clear width x building length. Gable-end soffit intakes, both ends, 100 mm (4 in.) clear width x rafter length. All air intakes should be bird- and rodent-proofed with a 90 mm (3½ in.) hinged closure flap. In the closed position, the closing flap dimension will allow a 12 mm (½ in.) opening for winter ventilation.

10. **STORAGE RACKS** – should be constructed above the top of the curb (datum line) so that in the event of an accidental spill or leak, the container is not in direct contact with the floor.

11. **FROST PROTECTION** – if chemicals are stored that are susceptible to freezing, an insulated cabinet 600 x 900 x 1,200 mm (2 x 3 x 4 ft.), or sized to suit, should be constructed and heated with two low-wattage electric bulbs.

OTHER FEATURES

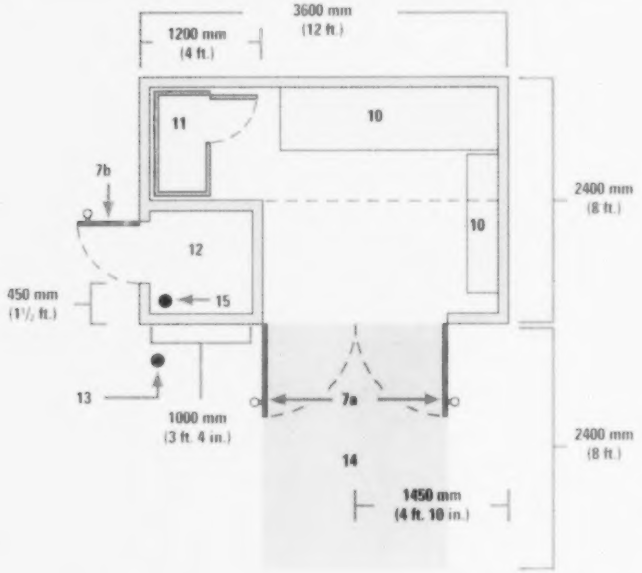
12. **ANTEROOM** – with hooks or shelves or lockers for the storage of respirators, disposable gloves, coveralls, goggles, first-aid supplies, personal gear, etc. Anteroom must be sealed off from the adjoining pesticide storage area (e.g., for the common wall, use a sill gasket between top of raised concrete curb and the stud wall plate). Internal walls to continue in height to the underside of the roof and should include a vapour barrier and internal sheathing. Caulk all seams to ensure air isolation from the pesticide storage room. Size of room to be 1,200 x 1,200 mm (4 x 4 ft.) or to suit. The anteroom will utilize the sidewall and gable-end soffits for continuous ventilation.

13. **FROST-FREE WATER HYDRANT** – to be located outside the building. A backflow valve/siphon preventer (self-draining type) to be installed on discharge end of hydrant.

14. **AN OPTIONAL CONCRETE RAMP** (broom finish) – can be formed with a finished elevation equal to the top of the curb. This feature would facilitate loading/unloading of storage with a front-end loader.

15. **FIRE EXTINGUISHER** – should be of the ABC type, and should be located in close proximity to but not in the pesticide storage building.

PLAN FOR FARM-BUILT FREE-STANDING PESTICIDE STORAGE – AERIAL VIEW



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OTHER FEATURES

12. **ANTEROOM** – with hooks or shelves or lockers for the storage of respirators, disposable gloves, coveralls, goggles, first-aid supplies, personal gear, etc. Anteroom must be sealed off from the adjoining pesticide storage area (e.g., for the common wall, use a sill gasket between top of raised concrete curb and the stud wall plate). Internal walls to continue in height to the underside of the roof and should include a vapour barrier and internal sheathing. Caulk all seams to ensure air isolation from the pesticide storage room. Size of room to be 1,200 x 1,200 mm (4 x 4 ft.) or to suit. The anteroom will utilize the sidewall and gable-end soffits for continuous ventilation.
13. **FROST-FREE WATER HYDRANT** – to be located outside the building. A backflow valve/siphon preventer (self-draining type) to be installed on discharge end of hydrant.
14. **AN OPTIONAL CONCRETE RAMP** (broom finish) – can be formed with a finished elevation equal to the top of the curb. This feature would facilitate loading/unloading of storage with a front-end loader.
15. **FIRE EXTINGUISHER** – should be of the ABC type, and should be located in close proximity to but not in the pesticide storage building.

STORAGE

Prefabricated storages are portable and ready-to-use.

PREFABRICATED FREE-STANDING

These are available in precast concrete, steel and wood.

TYPE	COST
Precast concrete – a range of available sizes (40-100 sq. ft.)	
8 ft. 4 in. x 5 ft. 6 in.	$2,000-$2,500
7 x 12 ft.	$4,000-$5,000
Steel – range of sizes available (can be customized)	
10 ft. x 8 ft.	$5,000-$6,000
Steel – woodframe, steel-clad, 8 x 8 ft.	$2,000-$3,000*

PROS	CONS
• can be delivered to site ready to use – no construction time, planning, etc.	• must accept storage as designed, i.e., size, materials, etc.
• acceptable storages meet requirements of the Pesticides Act • prefabricated storage costs can be competitive with on-farm constructed units • portable – easily moved to another site (in most cases)	• shipping charges can be high, especially for heavy units shipped a long distance

OTHER STORAGE TYPES

TYPE	COST
Wood frame, steel-clad 8 x 10 ft.	$3,500-$4,000
OMAFRA Plan – 8 x 12 ft.	$2,500-$3,500
Cabinet – old freezer with refrigerant removed	$400*
Farmer fuel storage	$400-$500**
Septic tank conversion	$1,500-$1,800**

***Assembly not included in this price for these storage units.**
****A cost for farmer labour has been incorporated.**

STORAGE

WHAT TO LOOK FOR IN PURCHASING A PREFABRICATED STORAGE

Refer to farm-built free-standing pesticide storage design criteria that are described on pages 22 to 25. Key considerations are:

- human safety
- a floor design that provides containment
- adequate ventilation
- sufficient floor area
- make sure that it meets the requirements of the pesticide legislation before you buy.

STORAGE WITHIN ANOTHER BUILDING

This can be a practical option for some growers. The steps for construction criteria for location are the same as other storage types.

Make sure you ventilate to the outdoors and have an outside entrance to the storage area.

One difference to keep in mind is that a firewall must be constructed between the storage area and the remainder of the building. Firewalls are designed to slow the spread of fire from one area to another. When pesticide storages are built as part of an existing structure, they require at least a one-hour rating. However, refer to your provincial or state building code for proper specifications.

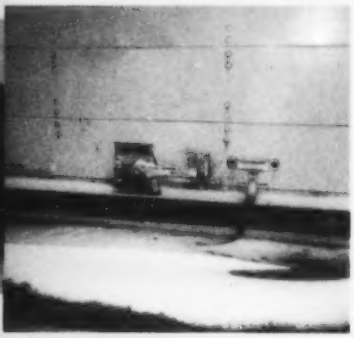
This prefabricated storage meets the requirements for safety, size, and environmental protection.

Examples of interior wall construction having a minimum one-hour fire rating include:

1. **2 x 4 in. wood studs @ 16 in. o.c.**
   4.5 mm (3⁄16 in.) asbestos cement board over 9.5 mm (3⁄8 in.) gypsum wallboard (both faces)
2. **2 x 4 in. wood studs @ 16 in. o.c.**
   two layers of 12.7 mm (1⁄2 in.) gypsum wallboard with joints taped and filled (both faces)
3. **2 x 4 in. wood studs @ 16 in. o.c. with absorptive material**, i.e., mineral fibre processed from rock or slag with a mass of at least 1.22 kg/m^2 (0.25 lb./ft.^{2}) and completely filling cavity wall, 15.9 mm (5⁄8 in.) special fire-resistant type X gypsum board with joints taped and filled (both faces)
4. **140 mm (5½ in.) hollow concrete blocks (normal weight aggregate)** – this can be a practical option for some growers. The steps for construction and criteria for location are the same as other storage types.

Built-on storages require ventilation to the outside, an outdoor entrance, and proper firewalls.

STORAGE



Transport trailers – if properly locked and signed – may serve as temporary storages.

TEMPORARY STORAGE

A temporary storage can be set up outside for large bulk containers that are weatherproof. The area must be fenced, have a warning sign posted, and be secure enough to deny access to unauthorized persons. They may also be stored on a transport trailer. Make sure that the site is not a hazard to wells or watercourses in case of a spill. These should not be used for permanent storage of pesticide products.

WORKER SAFETY AREA

People who handle pesticides on a regular basis need a worker safety area or anteroom. The size of the safety area and the equipment required depends on the number of workers and the types of products handled. The area should be close to the storage and mixing/loading facility and provide things like:

- ▶ emergency showers
- ▶ eye flush fountains
- ▶ up-to-date pesticide first-aid kits
- ▶ spill cleanup kits
- ▶ Material Safety Data Sheets (MSDS)
- ▶ personal protection equipment.

If the worker safety area is in the same building where pesticides are stored, a separate room (ventilated separately to the outside) with a separate outside exit door must be provided so that personnel do not have to go through the storage area to enter or exit the worker safety area.

EMERGENCY SHOWERS AND EYEWASH

- ▶ locate adjacent to storage and handling facilities
- ▶ place in easily accessible area with no obstacles
- ▶ water capacity: for showers – 10-30 gpm
  for eyewash – 2-5 gpm

STORAGE

STORAGE PRACTICES

Observe and comply with the following management practices when planning a pesticide storage facility for your farm:

- store all pesticides in their original labelled containers
- keep containers properly labelled
- monitor the condition of containers and check for leaks
- minimize quantity of pesticides stored – at most, buy only what you need for each season
- keep an inventory of your stock to inform emergency response personnel in case of fire or other emergency – make sure the inventory is accessible but away from pesticide storage
- prepare a written spill emergency/contingency plan, plus an emergency contact list, and locate in an accessible location on the farm
- make available absorbent material (such as dry sawdust, soil, or kitty litter) in sufficient quantity to clean up any spills or leaks from containers
- put a clean plastic bag around any damaged bag – close it securely and label it with all pertinent information.

Do not store pesticides in any container that was previously used for food or drinks.

EMERGENCY PREPARATION

EMERGENCY CONTACT LIST

Prepare and post a list of who to call in an emergency.

Farm manager (______) ______________________________

Assistant farm manager (______) ______________________________

Family physician (______) ______________________________

Alternate family physician (______) ______________________________

Ambulance (______) ______________________________

Emergency response team (______) ______________________________

Fire chief (______) ______________________________

Regulatory agency (______) ______________________________

Law enforcement officials (______) ______________________________

Spills Action Centre (______) ______________________________

Poison Information Centre (______) ______________________________

Hospital (______) ______________________________

Prepare a written spill emergency/contingency plan plus an emergency contact list. Keep it in an accessible location on the farm.

STORAGE

EMER
TU
RGENCY
TUBE

Emergency tubes are weatherproof storage containers for emergency plans.

EMERGENCY RESPONSE PLAN / SPILLS CONTINGENCY PLAN

Your plan should contain the following information:

- emergency contact list
- directions to site
- name, address
- site plan
- inventory, quantity and location of pesticides
- location of emergency equipment and supplies
- location of personal protection equipment
- labels and MSDS sheets for all pesticides, plus manufacturers' emergency numbers
- local reporting procedures for spills.

In an emergency, the local fire department would benefit if it had information on your storage location and the products normally stored in it. The fire chief will appreciate your interest in his/her department's safety in the event of a fire, and can help with site and fire plans.

Send copies to: facility, house of owner/operator, fire department, and police.

PESTICIDE FIRES IN STORAGE AREAS

A fire in a pesticide storage area can be extremely dangerous. There is the hazard of the fire itself, plus the additional danger of pesticide poisoning and contamination. The resulting smoke may contain toxic fumes, and water used to control the fire may become contaminated, posing an environmental threat if not contained.

Prepare for the possibility of a fire. You will have a greater chance of reducing health hazards and environmental contamination.

If a fire occurs, the priority is to get everybody out and notify the fire department. Do not take unnecessary risks in fire-fighting. It is wiser to wait for the fire department than to risk being poisoned or injured.

Refer to the *EFP Contingency Plan* publication and the *Grower Pesticide Safety Course* manual for further details.

STORAGE

STORAGE DURING TRANSPORTATION

The purpose of the legislation surrounding the transport of pesticides is to ensure human safety and prevent spills. Check with local authorities to ensure that you adhere to transportation requirements of related legislation.

In summary:

- be certain that anyone transporting pesticides is trained in safety procedures, shipping documents, and the use of placards
- lock pesticides in the trunk or storage area of the vehicle, and not in the cab or passenger area – if the pesticide cannot be locked securely, an authorized person must stay with the vehicle
- observe all restrictions on pesticide quantities (e.g., warning sign on vehicles transporting in excess of 500 litres)
- place a warning sign that states **Chemical Storage – Authorized Persons Only** on an unattended, parked vehicle that contains pesticides
- keep pesticides separate from other products
- report all accidents that represent a danger to humans, property, or the environment.

Spills and human safety are a concern when transporting pesticides. Take the necessary precautions.

HANDLING

This chapter covers:

- **handling principles**
- **mixing/loading systems**
- **best management practices for mixing/loading**
- **what to do in case of a spill**
- **managing empty containers.**

Pesticide handling activities pose the greatest risk to human safety because handlers are exposed to concentrated forms of pesticide products.

Permanent handling facilities should be located near storage areas and should be designed to prevent runoff.

PRINCIPLES

Pesticide handling is the on-farm transfer, mixing, and loading of pesticides and pesticide mixtures.

These activities pose the greatest risk to human safety because handlers are exposed to concentrated products. The environment is also at risk because pesticide spills are most likely to occur at this stage.

For these reasons, all farmers should implement best management practices for handling.

To help you be ready in the event of a spill, there are also best management practices for contingency planning, personal safety, and cleanup.

When designing or planning a pesticide handling system, consider the following points.

PRINCIPLE	CONSIDERATIONS
LOCATION	• locate permanent site as near as possible to pesticide storage and other equipment • keep handling as far away as possible from wells, watercourses, wildlife habitat, and livestock feed
PRACTICALITY	• consider permanent system or other approach • contrast capital costs with management costs • ensure a protected source of water is nearby • size system to fit sprayer for loading and cleaning tasks
SAFETY	• consider systems (such as closed systems or soluble packages) that require less handling • wear protective clothing and equipment • develop and post contingency plans in the event of spills • keep away from children, livestock, pets, and wildlife
ENVIRONMENTAL PROTECTION	• contain all liquids • prevent runoff from spills to environmentally sensitive areas • prevent backflow to water sources (e.g., wells) • prevent runoff to unprotected wells • implement management practices that prevent spills and overfills • implement management practices that collect rinsate and sumpage, and dispose of pesticide waste materials properly

HANDLING

MIXING/LOADING SYSTEMS

Mixing/loading systems are one or a combination of structures, facilities, equipment or approaches used to mix and load pesticide products in sprayers or other application equipment.

There are three main types of mixing/loading systems:

- permanent mixing/loading facilities
- mixing/loading at application site
- portable pads and trays.

Permanent facilities are impermeable concrete pads designed to contain spills and overflow and/or contaminated precipitation. When they are properly bermed, they also divert uncontaminated surface runoff from the mixing/loading structure. These systems are usually sized to fit equipment, and for convenience are located near storage areas. Liquid that is contained within the mixing/loading facility is called a sump mixture.

A sump mixture:

- should contain the tank mix remnants or sprayer rinsate of one product or approved product mix
- should not be mixed with other pesticide products
- should be stored in separate containers and labelled
- should be applied to labelled crop or used as part of the next tank using the same pesticide product(s).

Each sump mixture should be collected and stored in a separate container following the use of that pesticide (and before a different pesticide is used). This mixture can then be used to apply to that labelled crop or used as mix water for the next batch of similar pesticide to be made.

A sump is a pit or reservoir that serves as a receptacle for liquids. Sumps are designed for short-term recovery and transfer, not for storage.

Permanent mixing/loading facilities should be constructed with impermeable concrete to contain spills.

HANDLING

Avoid contaminating water sources by using nurse tanks.

MIXING/LOADING AT APPLICATION SITE

Permanent sites for mixing/loading are the preferred system for environmental protection. However, due to practicality or cost, many operators do mixing/loading in the field or orchard – provided the operation is conducted no closer than 90 metres (300 ft.) to surface water sources. Two acceptable methods are:

- move the mixing/loading area on a regular basis – provided recommended separation distances are observed
  - acceptable method for large-scale (field crop) applications when you bring source of water to mixing/loading site

OR

- excavate or berm a shallow area for in-field mixing/loading and line this area with an impervious liner
  - be sure to bring source of water to mixing area and observe recommended separation distances.

By attaching tanks of water to his field sprayer, this producer is able to rinse out his tank and apply rinsate to the sprayed fields.

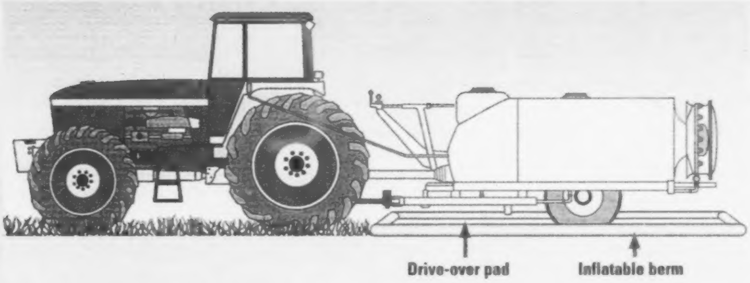
PORTABLE PADS AND TRAYS

There are several commercial products available to help with mixing/loading at site of spray application.

Portable pads can be used at temporary sites to contain spills from overflow – provided they are used at least 90 metres (300 ft.) from any surface water. They are fabric liners with berms around the perimeter. Ensure that purchased portable pads are recommended for use with agricultural chemicals. After use, they can be cleaned and stored for reuse.

Flexible or inflatable synthetic drive-over pads are designed to catch drips and spills (like an inflatable swimming pool).

Shallow (15 centimetres [6 in.] curb) rigid plastic or fibreglass trays have built-in ramps or elevated vehicle tracks. The trays measure from 2.4 to 3 metres by 4.8 to 6 metres (8-10 x 16-20 ft.).



Portable pads are fabric liners with berms around the perimeter.

HANDLING

PERMANENT MIXING/LOADING FACILITIES

SITE SELECTION

To be safe, permanent facilities should be at least 90 metres (300 ft.) from:

- surface water sources
- wetlands and other wildlife habitat
- wells

OR

Refer to pages 16 and 17 for specific information, including soil materials, slope, depth to bedrock, water table, and distance to wells and surface water sources.

FLOOR AREA REQUIREMENTS

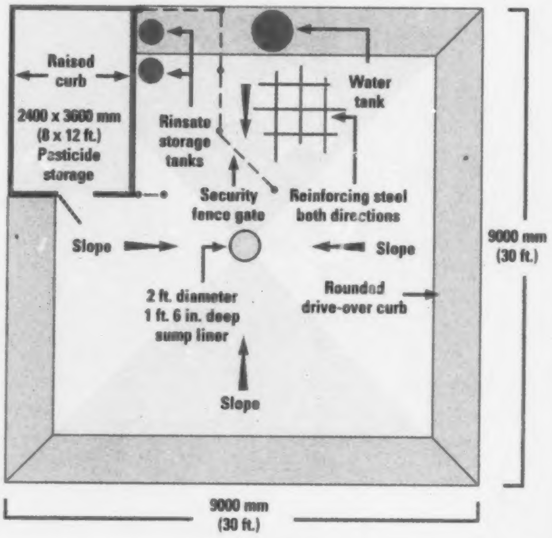
Floors for combination mixing/loading pads have rounded curbs at the perimeter for access and are sloped to a central sump.

Floor-area size requirements should be based on type of application equipment and expected use of the pad. For example, aerial sprayers or wide, hydraulic boom sprayers need more space. Further, if the area is to be used for unloading, cleaning and calibrating, the floor area should cover the boom width. Select the floor area based on your specific requirements. The guidelines below may assist you.

For a small, drive-across combined mixing, loading and storage system – such as one suitable for a field crop operation – select a pad with the minimum dimensions of 9.1 x 9.1 metres (30 x 30 ft.).

A combination pesticide storage/mixing/loading facility for aerial application could have a pad dimension of 18.2 x 18.2 metres (60 x 60 ft.) with an additional 6.1 x 18.2 metres (20 x 60 ft.) for the storage area. The pad size (excluding storage area) should never be less than 4.5 x 7.5 metres (15 x 25 ft.).

AERIAL VIEW OF A MIXING/LOADING PAD


Raised curb
2400 x 3600 mm
(8 x 12 ft.)
Pesticide storage
Rinsate storage tanks
Water tank
Security fence gate
Reinforcing steel both directions
Slope
Slope
2 ft. diameter
1 ft. 6 in. deep
sump liner
Rounded drive-over curb
Slope
9000 mm
(30 ft.)
9000 mm
(30 ft.)

Floors for combination mixing/loading pads have rounded curbs at the perimeter for access and are sloped to a central sump.

Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

HANDLING

PAD DESIGN AND CONSTRUCTION

SITE PREPARATION

- remove 15-25 cm (6-10 in.) of topsoil from site where pad is to be constructed
- ensure layer of soil below concrete pad is well-drained and compacted
- consider removing soils that swell (clays) or have high moisture-holding capacities (silt loams, loams, and clay loams), and backfilling with compactable, quick-draining coarser materials, e.g., pit-run gravel
- add 15-25 cm (6-10 in.) depth of granular fill to replace topsoil, and compact well
- note that berms and subsurface tiles may be needed in areas with naturally high water tables or in areas where runoff collects

PAD DESIGN

- size pads according to functions and application equipment
- choose materials for strength and impermeability, i.e., sealed, reinforced concrete pads
- ensure pads are sloped and curbed to contain and direct liquids
- size sumps to capture all liquids from spills, leaks, overfills, and cleanouts
- ensure curbs prevent surface water from flowing onto pad – curbs should be designed so that sill plates for open, roof-supporting walls can be readily erected
- design ramps for easy access by application equipment
- design curbed pads to hold at least 125% of volume of largest spray tank

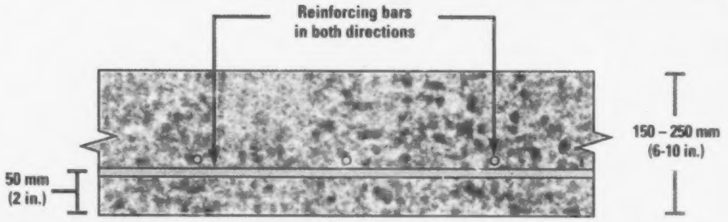
PAD CONSTRUCTION

- place 15 cm (6 in.) granular sub-base on top of sub-grade to cushion vehicle pressures, reduce expansion pressures from sub-grade, and improve drainage beneath the pad
- ensure proper pad strength for application equipment

SINGLE AXLE LOAD (lbs.)	CONCRETE SLAB THICKNESS (in.)	REINFORCED BARS & SPACING*
up to 20,000	6	#3 @ 10 in. o.c.
20,000-30,000	8	#4 @ 12 in. o.c.
30,000-40,000	10	#4 @ 10 in. o.c.

*** Install reinforcing bars at this spacing in both directions**
Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

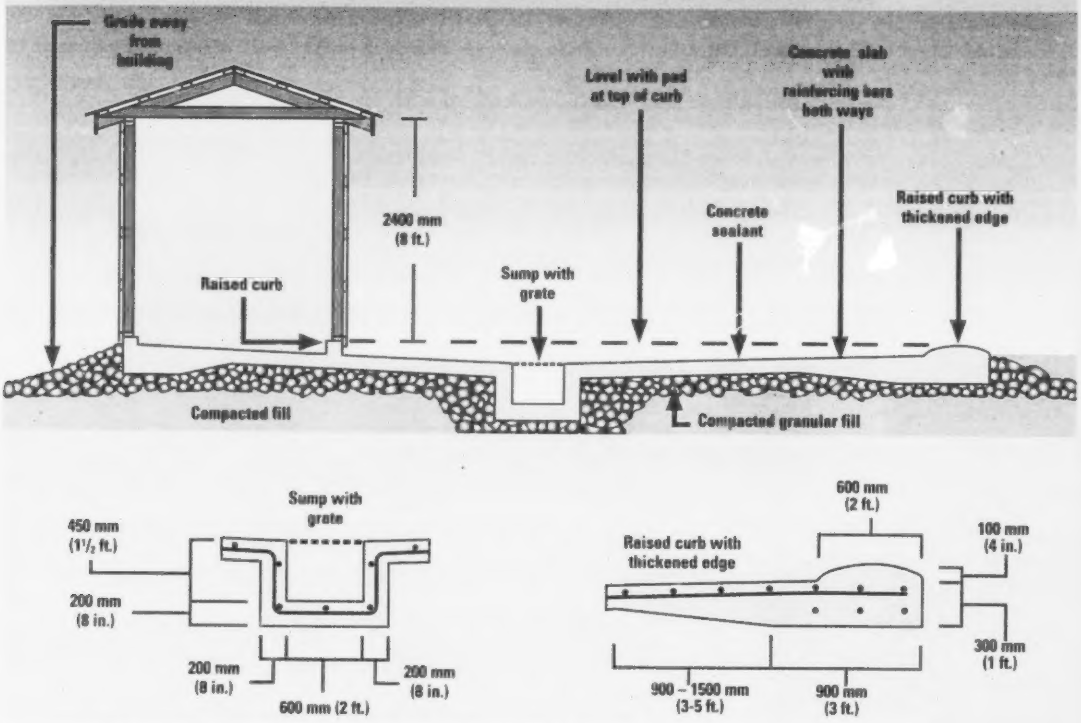
- use 30 MPa (4,000 psi) concrete and steel bars laid in both directions according to numbers above, for maximum strength
- place additional reinforcement bars around perimeter to support pad edges
- ensure concrete surface quality to withstand deterioration and reduce infiltration by liquids
  - avoid excessive joints with continuous-pour floors
  - finish with aluminum or magnesium float
  - coat with concrete-sealing products



Mixing/loading pad structural design. See table above for thickness and steel reinforcement requirements.

HANDLING

CROSS-SECTIONAL VIEW OF A MIXING/LOADING PAD


Grade away from building
Level with pad at top of curb
Concrete slab with reinforcing bars both ways
2400 mm (8 ft.)
Concrete sealant
Raised curb with thickened edge
Raised curb
Sump with grate
Compacted fill
Compacted granular fill
Sump with grate
450 mm (1½ ft.)
200 mm (8 in.)
200 mm (8 in.)
600 mm (2 ft.)
200 mm (8 in.)
600 mm (2 ft.)
Raised curb with thickened edge
100 mm (4 in.)
300 mm (1 ft.)
900 – 1500 mm (3-5 ft.)
900 mm (3 ft.)

Permanent mixing/loading pads require reinforcing bars laid both ways.

Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

SUMP

- slope floors to sump
- size sump to contain liquids deposited on floor area, i.e., spray tank, spillage, rinsate, contaminated water, etc.
- use curbed area of pad as containment volume
- line sumps with materials such as high density polyethylene (HDPE) or stainless-steel – liner type should be selected based on anticipated pesticide products to be used
- ensure sumps have shallow cone design for cleanout of liquids and sediment
- cover sumps with a structural grate for safety
- pump or drain sump by gravity to a storage system

PAD DESIGN AND CONSTRUCTION

SITE PREPARATION

- remove 15-25 cm (6-10 in.) of topsoil from site where pad is to be constructed
- ensure layer of soil below concrete pad is well-drained and compacted
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*** Install reinforcing bars at this spacing in both directions**
Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

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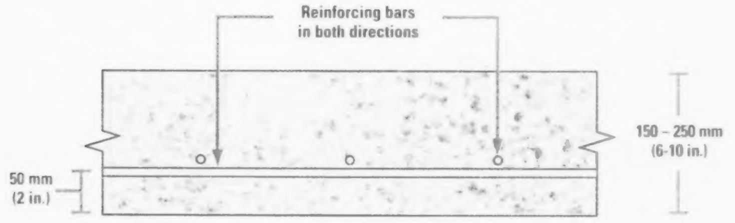
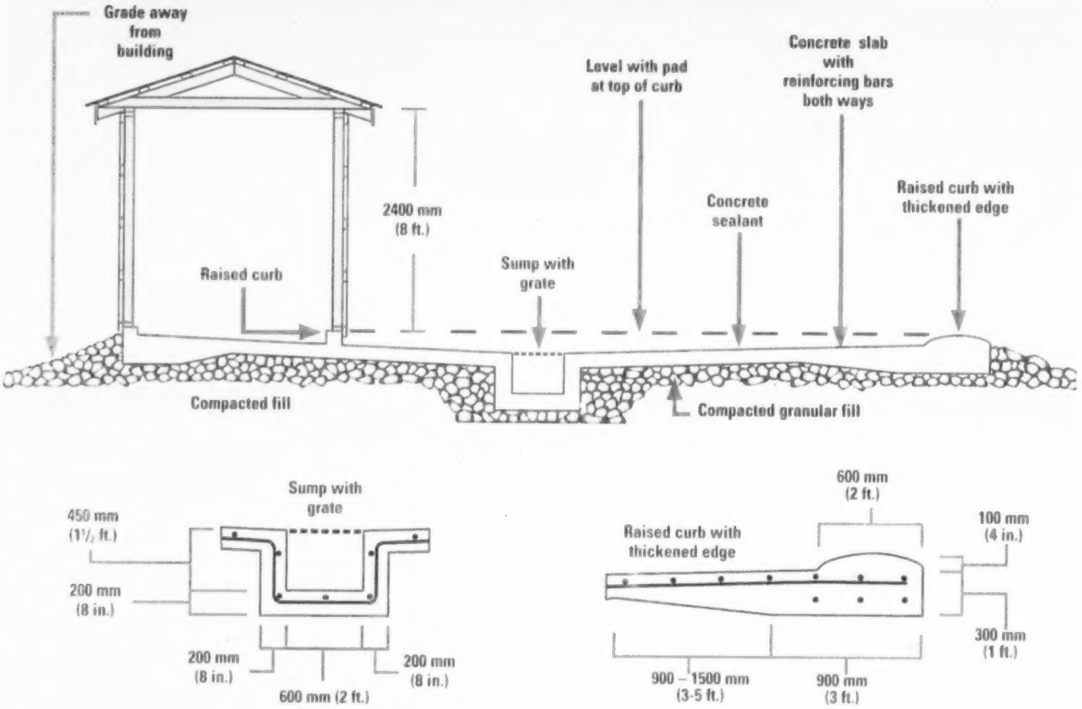
- ensure concrete surface quality to withstand deterioration and reduce infiltration by liquids
  - avoid excessive joints with continuous-pour floors
  - finish with aluminum or magnesium float
  - coat with concrete-sealing products



Mixing/loading pad structural design. See table above for thickness and steel reinforcement requirements.

CROSS-SECTIONAL VIEW OF A MIXING/LOADING PAD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- ensure sumps have shallow cone design for cleanout of liquids and sediment
- cover sumps with a structural grate for safety
- pump or drain sump by gravity to a storage system

Sprayer rinsate (rinse water) is wastewater from cleaning the inside of product containers, spray tanks, or other application equipment.

RINSATE STORAGE AND HANDLING CHECKLIST

☑ Sprayer rinsate and sump liquids require temporary storage prior to disposal.

☑ Rinsate storage tanks should be located adjacent to the mixing/loading area.

☑ Tanks of high density polyethylene or fibreglass (200-600 gal. volumes) are recommended. Smaller tanks provide greatest flexibility.

☑ Tanks and plumbing should be labelled and records kept to avoid cross-contamination of incompatible pesticides.

☑ Use temporary hoses with quick release connections to avoid contamination.

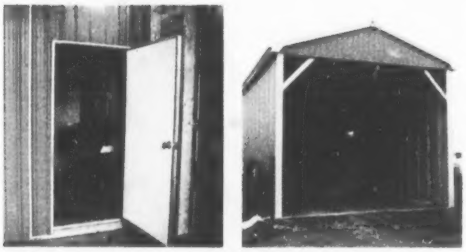
☑ Mount rinsate tanks 7.5-15 cm (3-6 in.) above pad height for easy access and observation.

ROOF DESIGN AND RAINWATER MANAGEMENT

Roofed mixing/loading areas are recommended to reduce the disposal dilemma of surplus tank mixes, rinsing wastes plus precipitation.

The best designs for cold humid climates are open-ended walled mixing/loading areas – they can be used for winter storage of pesticide application equipment.

An alternative to closed wall structures are 'roof-only' buildings with extended overhangs.



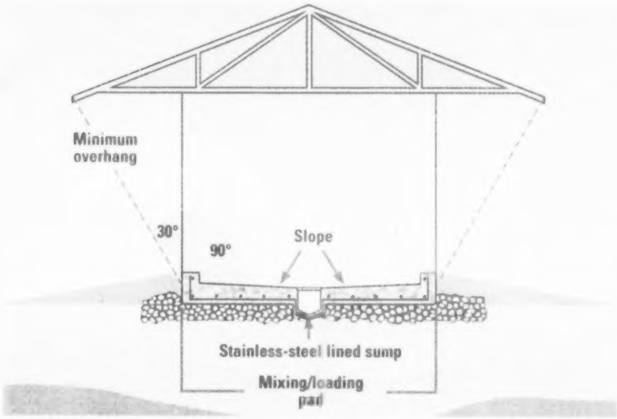
This producer converted a driveshed into a permanent covered storage and handling facility.

Pads should be constructed so that surface runoff is diverted away from the site:

- berms and raised pads are best
- drop inlet diversions for uncontaminated runoff must be designed to prevent any contamination from pesticides.

When considering roof options, remember:

- wood-frame, steel-clad roof systems are most common
- all-steel roof systems are a good option
- roof overhang should extend as much as possible to eliminate rain/snow problems – don't curtail height of entry for large equipment
- roof snow-load requirements for extra overhang length.



The cost of a roofed pad is much lower than the cleanup costs of a pesticide spill.

Source: *Designing facilities for pesticide and fertilizer containment. Mid-West Plan Service-37*

HANDLING

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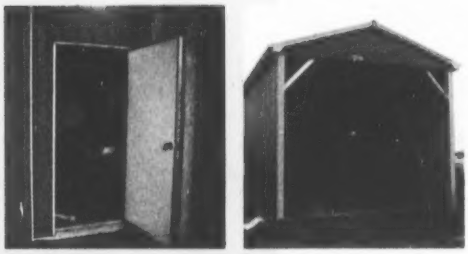
☑ Mount rinsate tanks 7.5-15 cm (3-6 in.) above pad height for easy access and observation.

ROOF DESIGN AND RAINWATER MANAGEMENT

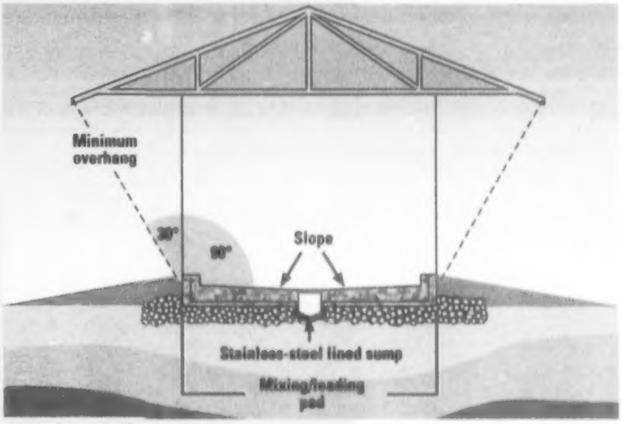


This producer converted a driveshed into a permanent covered storage and handling facility.

Roofed mixing/loading areas are recommended to reduce the disposal dilemma of surplus tank mixes, rinsing wastes plus precipitation.

The best designs for cold humid climates are open-ended walled mixing/loading areas – they can be used for winter storage of pesticide application equipment.

An alternative to closed wall structures are 'roof-only' buildings with extended overhangs.



The cost of a roofed pad is much lower than the cleanup costs of a pesticide spill.

Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

Pads should be constructed so that surface runoff is diverted away from the site:

- ▶ berms and raised pads are best
- ▶ drop inlet diversions for uncontaminated runoff must be designed to prevent any contamination from pesticides.

When considering roof options, remember:

- ▶ wood-frame, steel-clad roof systems are most common
- ▶ all-steel roof systems are a good option
- ▶ roof overhang should extend as much as possible to eliminate rain/snow problems – don't curtail height of entry for large equipment
- ▶ roof snow-load requirements for extra overhang length.

HANDLING

BEST MANAGEMENT PRACTICES FOR MIXING/LOADING

Effective mixing and loading systems require the best choices for facilities, equipment, and management practices.

PREVENTIVE MAINTENANCE

Regularly inspect structures and equipment for wear and tear:

- check floor surfaces, valves, pumps, and seals
- repair structures and equipment as needed
- repair cracks in concrete by routing and sealing, injecting epoxy materials or other means.

Maintain drainage by keeping vegetation mowed and rodents away.

Clean up area to prevent buildup of pesticides.

Clean sumps to prevent corrosion and pump problems.

Prevent concrete deterioration by inspection and application of protective coatings.

HOW TO PREVENT BACKFLOW TO WATER SUPPLY

An accidental spill or backsiphoning of a chemical into your well or surface water can severely impair water quality (drinking, etc.) and may take an extended period of time to rectify. Immediate health problems can result. The effects of repeated exposure to these low levels of pesticides are unknown, but may produce health problems many years after the exposure.

Pesticide contaminants can also cause health problems for livestock and wildlife. Pesticide-contaminated water sources are unfit for irrigation.

This one-way valve attached at the faucet will prevent draining back to the water source.

HANDLING

Portable water tanks can be taken to application sites.

There are three ways to prevent backflow into wells.

WATER TANKS

Permanent, separate water tanks can be furnished in the storage/mixing/loading area.

Portable water storage tanks can be taken to application sites.

In both cases, water is pumped to them – eliminating all contact of pesticides with source.

GAPS

A 15 centimetre air gap between the hose and the top of the sprayer tank will allow tank filling, and eliminate the possibility of the filled tank (water or mixture) from draining back to the water source.

ANTI-BACKFLOW DEVICE

Devices such as check valves should be attached to any faucet that provides water to storage and handling systems.

The one-way valve prevents liquids from flowing back through the faucet and into the well.

An anti-backflow device may be as simple and effective as this farmer's innovation. The sprayer modification is placed over the tank opening and the hose is attached to the device during filling.

This volumetric hand pump will help producers add precise volumes and avoid splashes and spills.

HANDLING

HOW TO AVOID SPILLS AND HANDLING RISKS

☑ Make your movements slow and sure.

☑ Don't leave sprayer unattended when filling.

☑ Have a good loading platform on or beside sprayer.

☑ Check for leaks, defective hoses, and faulty valves. Maintain all application equipment regularly.

☑ Add chemicals to the spray tank carefully. Ensure that the loader is upwind of where the chemical is poured.

☑ Add chemicals slowly. Rapid pouring of liquid leads to splashes.

☑ Never lift or pour concentrates above waist height.

☑ Always half fill the spray tank with water and start agitation before adding any chemical to the spray tank.

☑ Add the remaining water with continuous agitation to assure thorough mixing. Don't overfill. An external water-level sighting tube is helpful.

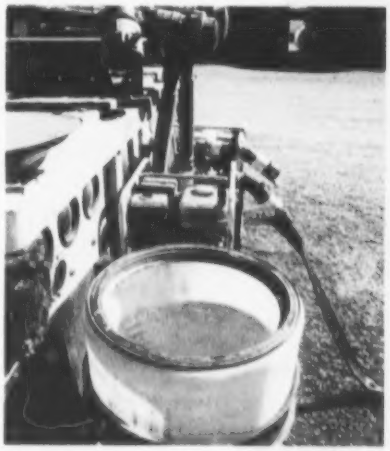
☑ If handling liquids, triple-rinse the empty container immediately and add the rinsate to the spray tank, or pressure-rinse directly into the spray tank.

☑ When triple-rinsing or pressure-rinsing, wear the same protective clothing and equipment used for mixing and loading.

☑ The use of soluble packaging that can be added directly to the spray tank with the pesticide reduces operator exposure and eliminates the need to rinse and dispose of containers. Make sure you agitate long enough so that all the packaging material is dissolved. Soluble packaging allows for mixing without risk to operator and eliminates container wastes.

A leak is a continuous low-volume discharge of a pesticide or pesticide mixture.

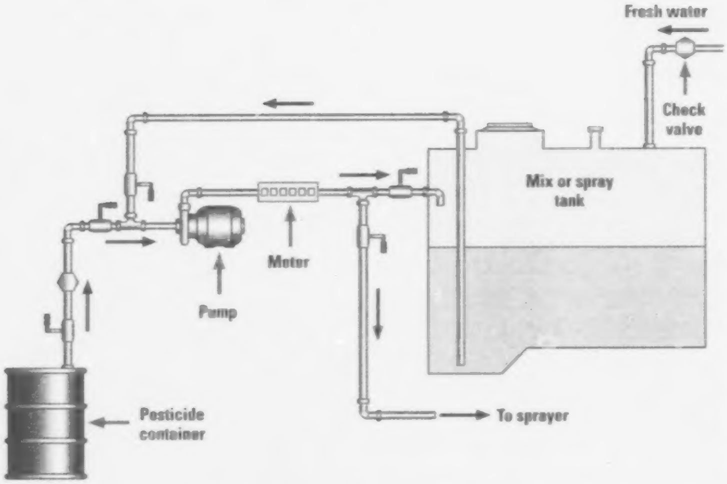
Never mix pesticides near your water well.



This grower attached a mixing tub to a nurse tank, allowing him to load herbicides, thoroughly mix the product, and rinse containers right in the field.

HANDLING

CLOSED MIXING SYSTEMS (CMS)



This diagram shows a closed mixing system (CMS). A CMS allows producers to mix and load pesticides without being exposed to them.

Source: *Designing facilities for pesticide and fertilizer containment, Mid-West Plan Service-37*

A CMS reduces the need for full protection equipment, and will help prevent backflow to water sources.

A CMS means you can mix and load pesticide solutions without exposure to pesticide materials.

It uses a vacuum to move materials through the system.

In a typical mechanical pump-type system, pesticides and water are drawn by the pump, through a metering system to the spray tank. From there, the mixture is pumped to the sprayer.

The pesticide is removed from a closed container. Empty containers can be triple-rinsed and rinsate added to the mix for application.

Monitoring systems can improve accuracy in pesticide measurement.

SAFETY CHECKLIST

☑ Keep children, pets and livestock away from mixing/loading areas.

☑ Know the product:
  - ▶ the health effects from pesticide contamination depend on the type of chemical and the amount of exposure
  - ▶ read product label to familiarize yourself with the chemical type you're using and what safety measures are needed.

☑ Have clean clothing and safety equipment as well as properly serviced respirators available for use by the loader/operator:
  - ▶ most user exposure occurs during handling.

☑ Use the proper tools for opening container, e.g., designated knives for bags and aluminum foil seals, and clean the tools after use:
  - ▶ don't use tools for other purposes.

☑ Wear chemical-resistant gloves (not leather) with cuffs turned back, since the main source of exposure is through the hands and forearms:
  - ▶ wear gloves when taking off chemical-laden aprons and other safety equipment
  - ▶ rinse gloves properly before taking them off
  - ▶ inspect gloves for holes and tears, and replace if necessary.

HANDLING

When mixing and loading pesticides, wear the proper safety equipment.

☑ Wear a chemical-resistant apron (not leather) to prevent exposure to the abdomen and upper legs:

- ▶ make sure the apron is long enough to cover boots, but not so long as to cause you to trip
- ▶ be careful around PTO with protective aprons.

☑ Proper safety equipment includes:

- ▶ chemical-resistant gloves and apron
- ▶ safety goggles
- ▶ waterproof boots
- ▶ properly serviced respirators
- ▶ face shield, mask
- ▶ goggles
- ▶ breathing apparatus
- ▶ boots.

HOW TO DECONTAMINATE APPLICATION EQUIPMENT

This device, when attached to a field sprayer, allows the producer to triple-rinse pesticide containers while channelling the rinsate immediately into the tank.

It's important to decontaminate spray tanks and booms when pesticide changes are being made.

Wear the same safety equipment (gloves, apron, etc.) as you would for mixing and loading.

We know that some chemicals such as the hormone-type herbicides – even in minute amounts – are injurious to many plants. We also know that some new herbicide chemistry is extremely active in very minute amounts.

Check with your chemical supplier and read the label for warnings and specific directions regarding the best procedure for decontaminating application equipment. If the equipment must be used for application of other chemicals, the following methods for cleaning are suggested.

The best sites for cleanouts are permanent mixing/loading pads followed by application to target crop at approximately 1% of the application rate. (Most tank mixes have a 10% concentration. Dilute water:rinsate @ 10:1 ratio to give 1% application rate.)

The next best is in the field where rinsate is applied at approximately 1% solution directly to target crop or headlands where you're working. Provided you never use the same spot twice, no significant pesticide accumulations should occur.

HANDLING

It's important to decontaminate application equipment when changing pesticides.

DECONTAMINATING APPLICATION EQUIPMENT

FORMULATION TYPE	METHOD
WATER-SOLUBLE HERBICIDES	1. Prepare mixture of 250 ml household ammonia to 7 litres of water. 2. Flush some of the solution through spray system, and out through boom or nozzles. 3. Let remainder stand overnight in spray tank. 4. Empty and thoroughly rinse the tank, hose, booms and nozzles. OR 1. Prepare mixture of 50 grams sal soda (sodium carbonate) or a washing soda to 7 litres water. 2. Add to spray tank and allow to stand at least 2 hours. 3. Discharge through spray booms or nozzles. 4. Rinse tank well. 5. Refill twice with water and empty through spray system each time. OR 1. Use commercial tank and equipment cleaner recommended on pesticide manufacturer's label
OIL-SOLUBLE FORMULATIONS ONLY	1. Add 750 ml kerosene, 50 grams washing soda, and 50 grams detergent to 7 litres of water. 2. Allow mixture to stand at least 2 hours. 3. Discharge through nozzles and rinse system twice with clean water. OR 1. Use commercial tank and equipment cleaner recommended on pesticide manufacturer's label.
OIL- OR WATER-SOLUBLE SOLUTIONS	1. Add 1 ounce of activated charcoal and 1 ounce of detergent to 7 litres water. 2. Shake well. 3. Discharge through boom.

HANDLING

HOW TO MANAGE RINSATE

Rinsate is the mixture of water that's contaminated with low concentrations of pesticide products. It may come from:

- ▶ rinsed containers
- ▶ sumps
- ▶ cleanout water or leftover tank mix
- ▶ previously stored rinsate
- ▶ spill cleanups.

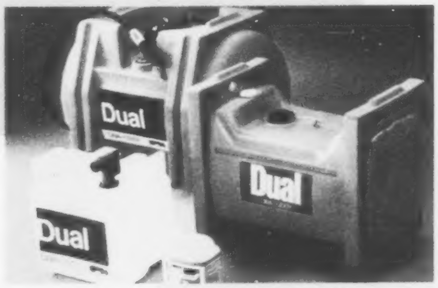
Rinsate becomes a waste problem when it cannot be recycled on the farm. The chart below gives some tips to manage rinsate effectively.

RINSATE 3 R's

REDUCE	REUSE	RECYCLE
• use water-efficient measures to clean tanks, such as: ◦ using power washers, e.g., pressurized hook or wand rinser ◦ avoiding spills with careful management ◦ roofing or otherwise covering the mixing/loading area ◦ using a CMS approach to mixing/loading	• use rinsate* as a diluent for future field tank mixes • dilute 10:1 water:rinsate** and apply to same field ◦ should not exceed a 1% solution ◦ this is within label rates and is well within accuracy of the meters for most application systems • if you plan to store the material, segregate and label recovered materials • apply label rates – and no more – to accommodate likely application of diluted surplus tank solutions or rinsate	• use bulk containers or CMS to minimize waste and mixed solutions ◦ some partially used bulk containers can be returned • recycle unused pesticides in original containers ◦ check with local authorities for recycling depot locations

* Non-segregated rinsate cannot be diluted and applied to field. There are unknown concentrations of products.

** Most tank mixes are already at 10% concentration.



Use bulk containers or cans to minimize waste and mixed solutions.

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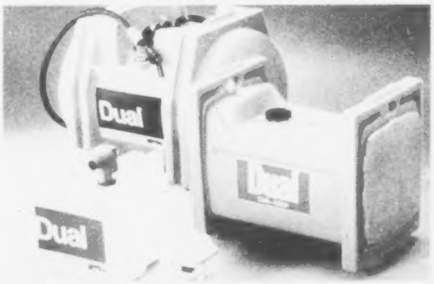


Use bulk containers or cans to minimize waste and mixed solutions.

* Non-segregated rinsate cannot be diluted and applied to field. There are unknown concentrations of products.

** Most tank mixes are already at 10% concentration.

HANDLING

A best management practice for tank rinsate disposal is to dilute the rinsate 10:1, and then to apply the diluted material to the same field.

Several techniques for disposing of rinsate are being researched:

- evaporation pits – lined pits of sand and gravel with perforated tiles
  - pesticide rinsate migrates upward where it breaks down over time
- rinsate recycle system – non-segregated rinsates are filtered and 'clean' water is reused for cleaning equipment or containers
- biodegradation two-chamber disposal system
  - the first is ozone to break down pesticide compounds, and the second a microbial digester
  - other systems combine evaporation and microbial breakdown.

These systems are experimental and not necessarily practical, cost-effective, or effective in cool, moist climates.

Before constructing such systems, be sure to seek approval from local agencies responsible for environmental protection.

PESTICIDE SPILLS

A spill is the discharge of a pesticide or pesticide mixture into the natural environment, from or out of a structure, vehicle, or other container, that is abnormal in quantity or quality in light of all the circumstances of the discharge.

If you use pesticide products, there's always the risk of a spill. Spills can be a safety hazard for staff, children, livestock, pets and wildlife. Spills pose the greatest environmental hazard for the contamination of groundwater, surface water, and fish and wildlife habitat.

Managing a spill effectively takes both proactive and reactive best management practices.

HANDLING

PREPARATION FOR POSSIBLE SPILL

CONTAINMENT

Materials to have at hand:

- soil or sand – for spreading to absorb liquids and form dams
- absorbent blankets and granules – to be piled to form dams
- booms (cylindrically shaped tubes), some with absorbent materials – to contain spills.

CLEANUP

Materials and equipment to have at hand:

- absorbents – limestone, peat, clays, kitty litter, activated charcoal, and absorbent blankets
- equipment – oil/water separators (for larger operations), personal safety equipment, shovels, and drums
- spill kits – purchase already made up, or make your own.

Commercial spill kits complete with absorbent materials and safety equipment are also available.

This homemade spills kit uses readily available materials for diking, containing, absorbing and disposing of contaminated materials from a spill.

WHEN A SPILL OCCURS

SAFETY

Address safety first by:

- protecting yourself from contact – use personal protection equipment and clothing
- if exposed, removing clothing and thoroughly cleaning up
- reading label – getting medical attention if recommended
- keeping people and animals away.

Step 1 Protect yourself and others.

CONTROL

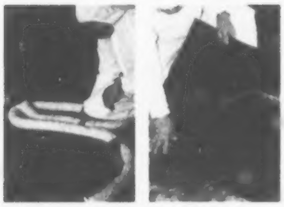
After addressing safety concerns, control the spill by:

- identifying the source
- if container is spilled –
  1. stopping leak (e.g., turn container upright)
  2. isolating container
  3. transferring remaining material to suitable container
- if tank overflows, turning off water source
- if tank upsets, containing the spill.

Step 2 Stop leak and control the spill.

HANDLING

CONTAINMENT



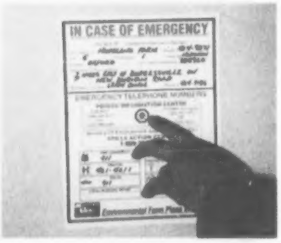
Once control is achieved, ensure containment by:

- making a dike with containment products such as clay, absorbent materials, or booms
- damming flow to sensitive areas such as wells, watercourses, and livestock areas.

Step 3 Contain the spill.

DO NOT HOSE DOWN PRIOR TO PROPER CLEANUP

REPORTING



IN CASE OF EMERGENCY

All spills must be reported. Use emergency plan numbers to report spill. Know your legal responsibilities.

Step 4 Report the spill.

The SPILLS ACTION CENTRE at 1-800-268-6060 has been established by the Ontario Ministry of the Environment to receive calls 24 HOURS A DAY.

CLEANUP

Step 5 Clean up the spill.

Decide how to clean up area by:

- contacting regulatory agency for procedures to follow
- consulting local authorities, product labels, product suppliers, spill kits, and your contingency plan.

Also:

- recover as much product as possible with pumps – filter and store for reuse
- use absorbents to sponge up liquids that can't be pumped and recovered – cover contaminated area with absorbents
- if a liquid pesticide product or mix spills onto soil, either decontaminate soil in place, or excavate soil and decontaminate at remote site – obtain some professional assistance
- store other used absorbent materials in designated waste drums, and dispose of them at hazardous waste sites – check with regulatory authorities for details and procedures.

HANDLING

EMPTY PESTICIDE CONTAINERS

Empty containers should never be reused. Don't give empty, rinsed containers to anyone, especially children.

All containers, including plastic bags, should be triple-rinsed.

Puncture all containers to render them unusable.

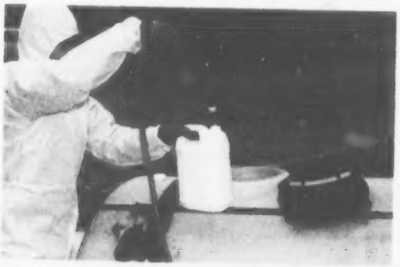
Cardboard and paper containers can be taken to designated landfill sites.

Metal and plastic containers should be taken to an authorized recycling depot. Consult your pesticide vendor for location of the site in your area.

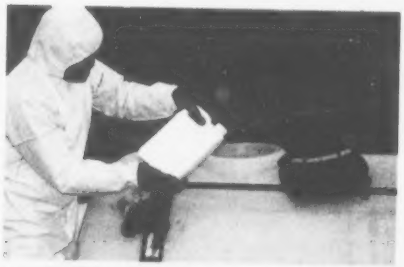
The following best management practices are alternatives to container disposal:

- use bulk returnable or refillable containers
- use water-soluble packaging that dissolves in the spray tank.

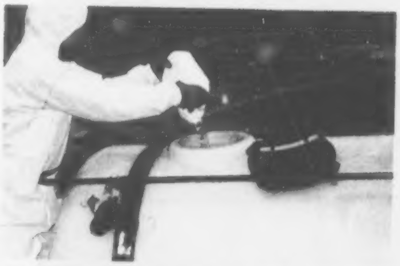
HOW TO RINSE EMPTY CONTAINERS



Step 1 Fill empty container 10% full with water. If you're using pressure rinse, rinse for at least 30 seconds.



Step 2 Close cap. Shake, rattle, and roll.



Step 3 Empty into spray tank. Then repeat Steps 1-3 twice more.

There are several devices on the market designed to puncture and, through the use of pressure, properly rinse pesticide containers.

Check with your local vendor for opportunities to recycle pesticide containers. Cleaned and rinsed containers are being recycled into plastic products such as fence posts.

APPLICATION

This chapter includes:

- **a brief overview of integrated pest management (IPM)**
- **the basics of how environmental and management factors can make the difference between coverage and drift**
- **best management practices for application**
- **best management practices for measuring, calibrating, and monitoring.**

It takes a working knowledge of the principles of sprayer technology, plus a toolbox of best management practices, to make pesticide applications work best – whether for horticultural crops, field crops, or livestock.

Determine your target. Know your product. Adjust for conditions. Hit your target. These are the keys to effective pesticide application. Follow these principles and you'll:

- ▶ save money
  - ▷ properly timed applications seldom have to be repeated
  - ▷ properly applied pesticides minimize waste – before and after application
  - ▷ maintain high quality, safe production at lower costs
  - ▷ effective applications help to maintain yields by controlling pests
  - ▷ successful pesticide use helps ensure timely harvests of quality produce
- ▶ protect the environment and wildlife
  - ▷ effective application reduces off-site impact to surface water and wildlife habitat
  - ▷ careful monitoring can help reduce direct exposure of wildlife to pesticides
- ▶ protect people, pets, and livestock.

Poorly timed application of pesticides to livestock can result in herd loss or product quality problems.

Best management practices for application are a good fit with your IPM program. Hitting the right pest at the right time with the right product will help you get the quality you're looking for.

If you think attention to sprayer technology isn't worth your time, count the cost of spraying your crop again.

APPLICATION

EFFECTIVE PEST CONTROL

Applying a pesticide may successfully control a pest. But it is likely that the pest will return unless more is done. Effective pest control takes knowledge, skills and careful planning to reduce the probability of pest resurgence. Learning and using the principles of integrated pest management (IPM) provides the opportunity to reduce pesticide application and increase effectiveness.

IPM is a process. And the following steps should be considered before applying pesticides.

Spraying by the calendar is not an effective means of pest control.

IPM STEP	MANAGEMENT CONSIDERATIONS
1. Diagnose the problem. 	• what is the pest? • where is the pest? • is it an economic pest problem? • when is the pest most susceptible? • what are the conditions that favour the pest?
2. Monitor the problem. 	• can the pest problem be predicted? • what monitoring techniques are suited to the pest? • what are the economic thresholds for the pest?
3. Control the problem. **Consider pest resistance potential and choose products from different families.**	• what control measures work, and under what conditions? • which combinations work best? • which are practical and cost-effective? • what should be known about pest control products? • are there alternatives to pesticides available? • how should the products be applied? • how much do you need? • how many days to harvest? • what is the re-entry interval?
4. Monitor the results. 	• did the treatments work, and is followup necessary? • is there any crop/livestock damage? • is there any off-site damage? • how will you measure or observe this? • is there any impact on beneficial insects, plants, fish, and wildlife?

For a general overview of IPM, see the Best Management Practices booklet, *Integrated Pest Management*.

APPLICATION

The goal of application is to hit the target with the right product at the right time.

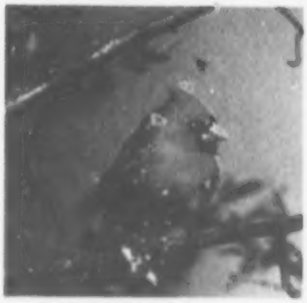
Reaching this goal requires an understanding of the principles affecting application: pest characteristics, crop or livestock development, product qualities, environmental conditions, and application technology.

TIMING

Timing is everything, or nearly everything. Timing relates to pest growth stage, pest pressure, the growth stage of the target crop, application of the pesticide product, and weather conditions.

FACTOR	WHY TIMING IS IMPORTANT	
FARM PRODUCT	• some **crops** are susceptible to damage at certain growth stages, e.g., some herbicides must be applied before crop emergence • because of **crop** or **foliage growth patterns** over the season, application techniques should be timed appropriately • to protect **beneficial** and **pollinating insects**, no insecticides should be applied during flowering • due to potential **residue problems**, no pesticide should be applied to the crop closer than the days-to-harvest interval • some livestock insecticides should not be used on **young stock** or on **lactating animals**	 **Spraying too close to harvest could lead to illegal residues.**
PEST CHARACTERISTICS	• for **insects**, know when pest is most susceptible ▫ if damage is already done during susceptible stages, it may be wasteful and futile to apply pesticides at this time ▫ also, make sure that you know when it will pay to spray • for **diseases**, protectant applications and preventative cultural methods are usually best • for **weeds**, know which growth stage of the target weed species is most susceptible to control • for some **livestock pests** (e.g., warble fly), susceptibility to control depends on life cycle stage and accessibility for treatment	 **Most insecticides for Colorado Potato Beetle are designed to provide control of the insect at the larval stage. The cost of an improperly timed application can be excessive ($25/acre and up) when you consider the cost of the first application, the crop damage incurred, and the cost of reapplication.** **Different growth stages of target weed species have varying levels of susceptibility to control measures.**

APPLICATION

FACTOR	WHY TIMING IS IMPORTANT	
PESTICIDE PRODUCT (KNOW YOUR PRODUCT)	• continued use of the same pesticide family can lead to **pesticide resistance** • contact pesticides require adequate **coverage**, so hitting the target is essential ◦ pesticide droplets may be required on both upper and lower leaf surfaces • **durability** – due to the chemical nature of some products, washing off, photodecomposition, and microbial decomposition will reduce durability • **additives** – some additives such as adjuvants may improve the ability of the products to spread and stick to target • **mode (of action)** – how a pesticide is intended to work will dictate time of application, e.g., protectant fungicides must have thorough coverage prior to the infection period for good control	 **Consider the relative toxicity of pesticide products to non-target species such as songbirds.**
WEATHER (ADJUST FOR CONDITIONS)	• contact and systemic pesticides with minimal residual qualities may wash off if it **rains** immediately after application • **temperature** can affect the breakdown of pesticides • apply at **time of day** when there is less interference by temperature • **high temperatures** and **low relative humidity** will evaporate spray droplets in their travels • **high winds** and fine sprays will result in drift to off-site areas • residual activity may be reduced by **photodecomposition** (intense sunlight)	 **Some pesticides are not useful at high temperatures. Spray in evening or morning.**

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PEST CHARACTERISTICS	• for **insects**, know when pest is most susceptible
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	  ○ also, make sure that you know when it will pay to spray
	• for **diseases**, protectant applications and preventative cultural methods are usually best
	• for **weeds**, know which growth stage of the target weed species is most susceptible to control
	• for some **livestock pests** (e.g., warble fly), susceptibility to control depends on life cycle stage and accessibility for treatment
	
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FACTOR	WHY TIMING IS IMPORTANT
PESTICIDE PRODUCT (KNOW YOUR PRODUCT)	• continued use of the same pesticide family can lead to **pesticide resistance** • contact pesticides require adequate **coverage**, so hitting the target is essential pesticide droplets may be required on both upper and lower leaf surfaces • **durability** – due to the chemical nature of some products, washing off, photodecomposition, and microbial decomposition will reduce durability • **additives** – some additives such as adjuvants may improve the ability of the products to spread and stick to target • **mode (of action)** – how a pesticide is intended to work will dictate time of application, e.g., protectant fungicides must have thorough coverage prior to the infection period for good control
WEATHER (ADJUST FOR CONDITIONS)	• contact and systemic pesticides with minimal residual qualities may wash off if it **rains** immediately after application • **temperature** can affect the breakdown of pesticides • apply at **time of day** when there is less interference by temperature • **high temperatures** and **low relative humidity** will evaporate spray droplets in their travels • **high winds** and fine sprays will result in drift to off-site areas • residual activity may be reduced by **photodecomposition** (intense sunlight)

Consider the relative toxicity of pesticide products to non-target species such as songbirds.

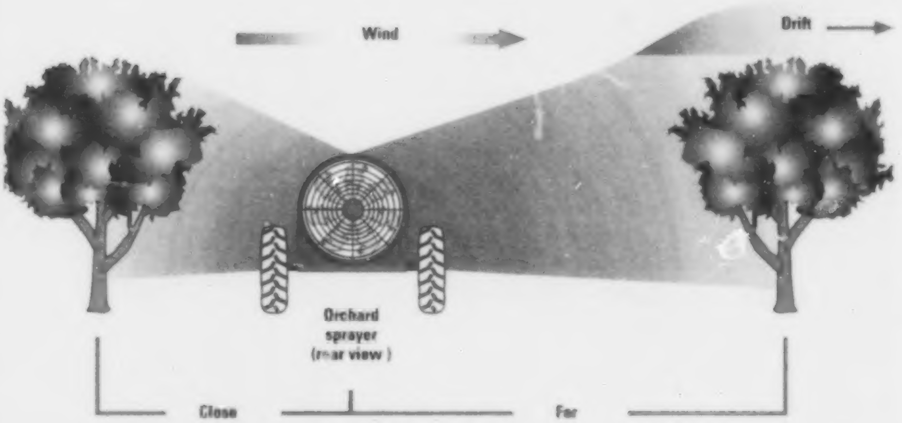
Some pesticides are not useful at high temperatures. Spray in evening or morning.

APPLICATION

COVERAGE VERSUS DRIFT

Maximize coverage and minimize drift. Do this and you'll have effective application. In most cases, factors that improve coverage will reduce drift.

FACTORS AFFECTING COVERAGE AND DRIFT



APPLICATION TECHNOLOGY FACTORS

- Water volume
- Pressure
- Droplet size
- Nozzle type
- Distance to target
- Travel speed
- Product selected

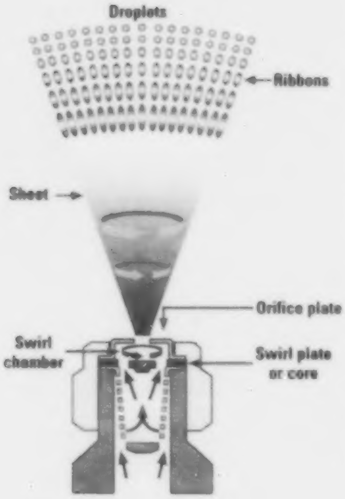
CONDITIONS DURING APPLICATION

- Canopy
- Wind
- Temperature
- Humidity
- Light

Generally the risk of drift is greater when a combination of the following factors coincide: low volumes, high pressures, small droplets, fast ground speeds, nozzles with small orifices, volatile chemicals, dense canopies, high winds and temperatures, and low humidity. Generally, coverage is greater when the reverse conditions exist.

Droplets are formed by forcing the solution through a nozzle orifice or by shearing it with a blast of high-speed air.

The solution leaves the nozzle as an unstable sheet or stream of liquid. This becomes thinner as it moves from the nozzle, and eventually breaks into droplets.



A pesticide spray is a pressurized application of a liquid solution or suspension of pesticide product. Sprays are actually atomized solutions consisting of a range of droplet sizes.

Drift can cause off-site damage.

COVERAGE VERSUS DRIFT – APPLICATION TECHNOLOGY FACTORS

FACTOR	COVERAGE	DRIFT
VOLUME		
• HIGH	• increased coverage (can also cause runoff)	• less drift
• LOW	• less coverage	• increased drift
PRESSURE		
• HIGH	• will improve coverage if the droplets reach the target	• increased drift because of force and reduced droplet size
• LOW	• use lowest pressure that still ensures proper coverage • lowest pressure to maintain spray angle	• reduced drift
DROPLET SIZE		
• LARGE DROPS (large nozzle orifice)	• fair coverage ○ may shatter ○ may bounce off ○ less penetration, less evaporation ○ fewer droplets ○ may run off	• high falling velocity • less drift hazard
• SMALL DROPS (small nozzle orifice)	• good coverage ○ better penetration ○ more droplets ○ more evaporation	• higher drift hazard • low falling velocity
NOZZLE TYPE		
• FULL CONE	• moderate coverage	• moderate drift
• HOLLOW CONE	• good coverage	• more drift
• FLAT FAN	• moderate coverage	• moderate drift
• FLOOD	• fair coverage	• less drift
DISTANCE TO TARGET	• closer distances provide better coverage	• greater distances → higher drift
TRAVEL SPEED		
• FAST	• poor coverage – but more acres/hour	• increased drift risk
• SLOW	• better coverage – but fewer acres/hour	• decreased drift risk
PRODUCT SELECTED		
• HIGH VOLATILITY ADJUVANTS	• may compromise coverage • may improve coverage • may alter droplet size • may alter spray pattern	• more vapour drift • reduce drift

This chart is a generalization only. A desirable compromise is reached when the adjustment of application equipment and practices integrates more than one factor.

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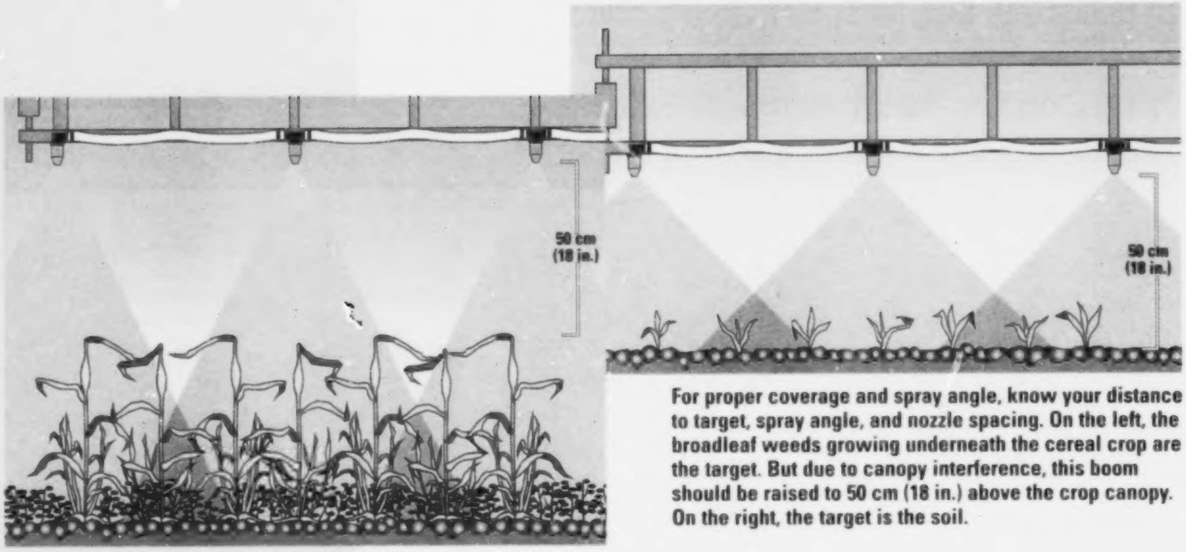
APPLICATION


50 cm
(18 in.)
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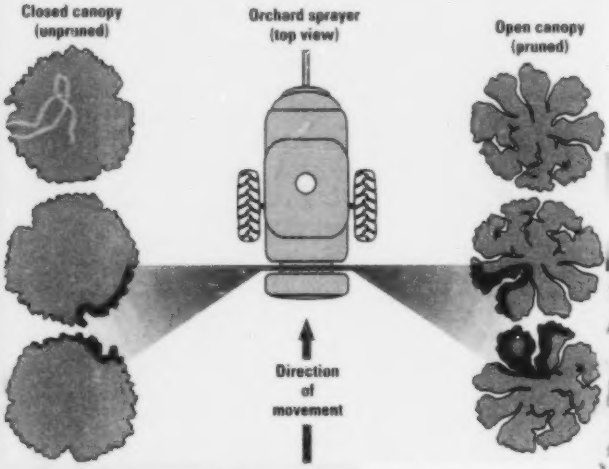
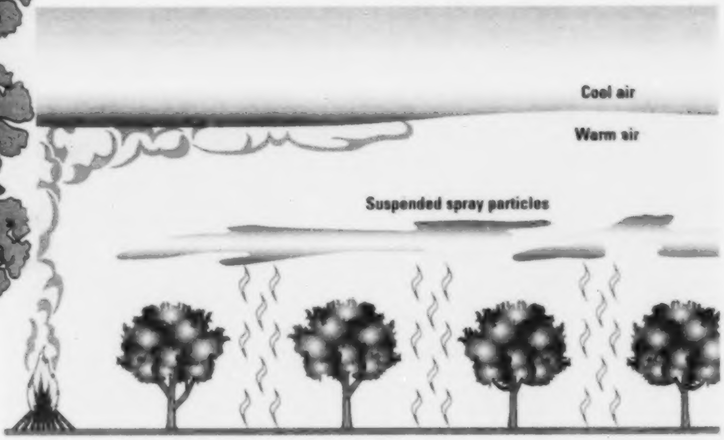
For proper coverage and spray angle, know your distance to target, spray angle, and nozzle spacing. On the left, the broadleaf weeds growing underneath the cereal crop are the target. But due to canopy interference, this boom should be raised to 50 cm (18 in.) above the crop canopy. On the right, the target is the soil.


Closed canopy
(unpruned)
Orchard sprayer
(top view)
Open canopy
(pruned)
Direction
of
movement

Coverage increases when canopies allow for better penetration. Pruning helps.


Cool air
Warm air
Suspended spray particles

Temperature inversions occur when warm air is trapped near the surface by cold air, as evidenced by the unique pathway of smoke from the burning of pruned material. Avoid spraying during temperature inversions – when conditions cause smoke to behave as shown, small droplets will drift off-site.

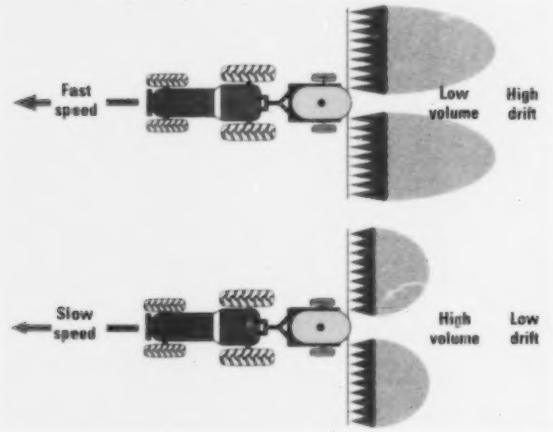
APPLICATION

DISTANCE TO TARGET

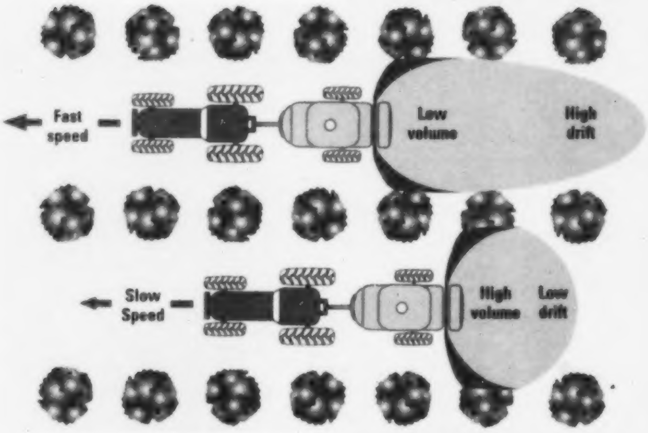
The greater the distance from nozzle to target, the poorer the coverage and the greater the risk of drift. When small droplets have greater distances to travel:

- ▶ the increased time increase risk of off-target deposition
- ▶ wind and air movement increase with heights.

VOLUME AND TRAVEL SPEED


Fast speed
Low volume
High drift
Slow speed
High volume
Low drift

At a given pressure, there is a greater risk of drift with low volumes and fast ground speeds.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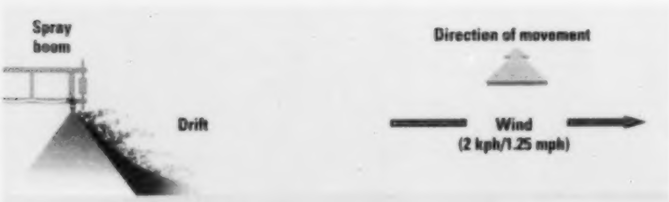
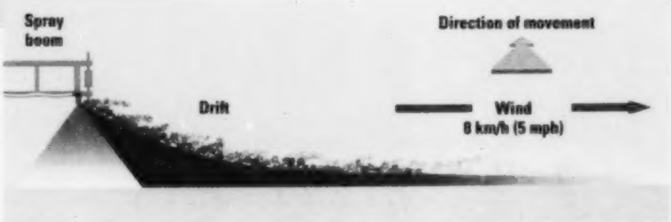
DROPLET DIAMETER, WIND SPEED, AND DRIFT

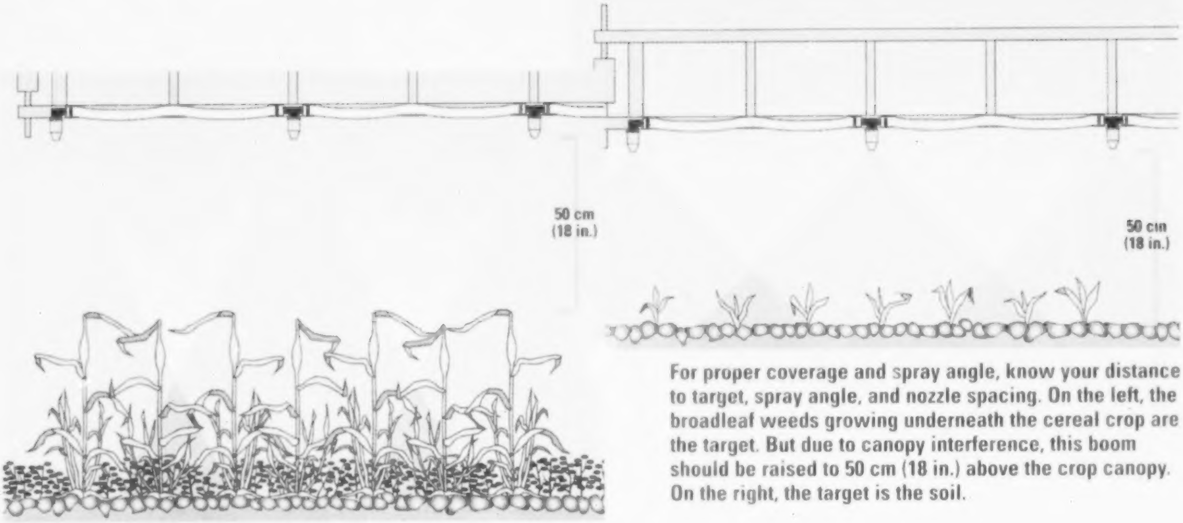

Spray boom
Direction of movement
Drift
Wind
(2 kph/1.25 mph)

Mist-size and coarse droplets do not drift far from target when winds are at very low speeds.


Spray boom
Direction of movement
Drift
Wind
8 km/h (5 mph)

Under moderately windy conditions, mist-size (100 microns) droplets can move considerable distances downwind from the source. Coarse droplets will only move slightly off-target.

APPLICATION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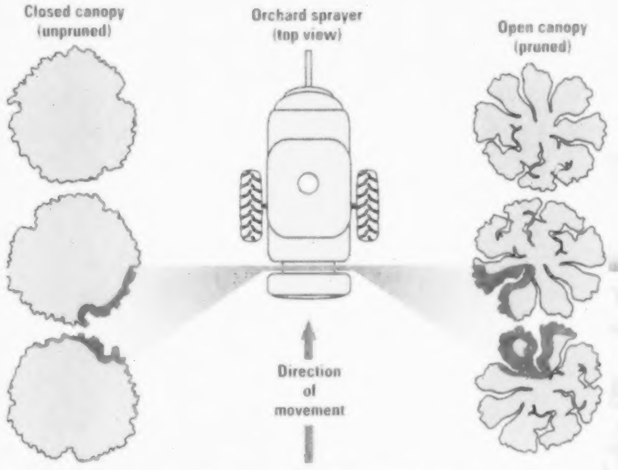
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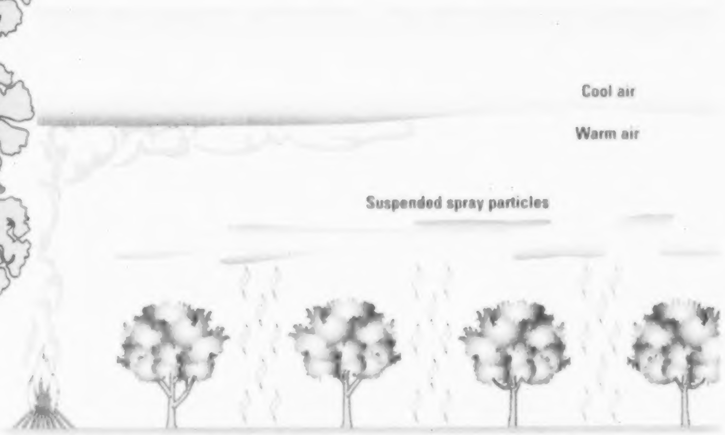
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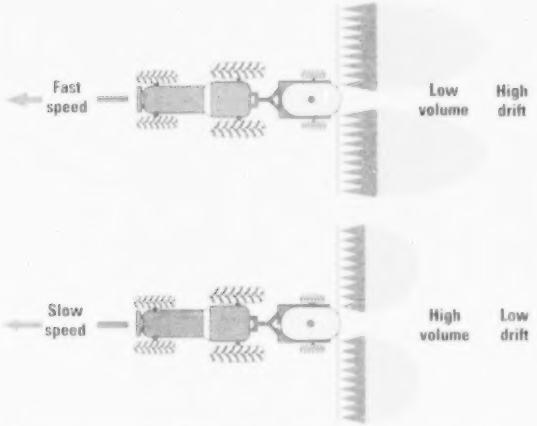
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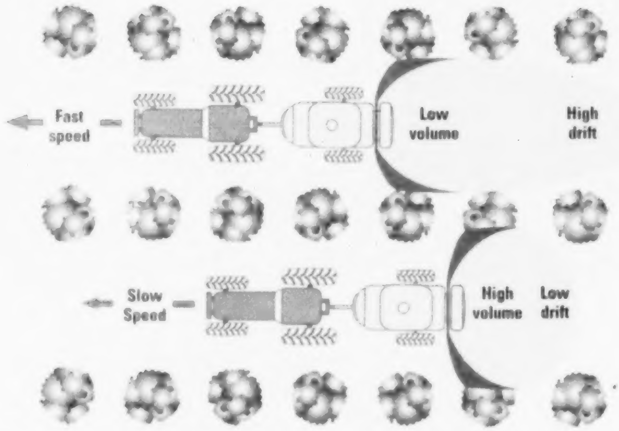
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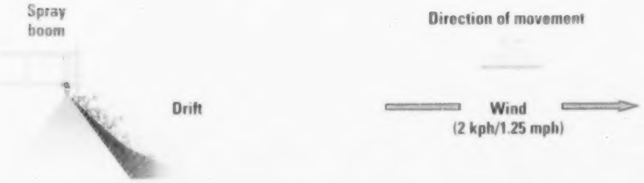
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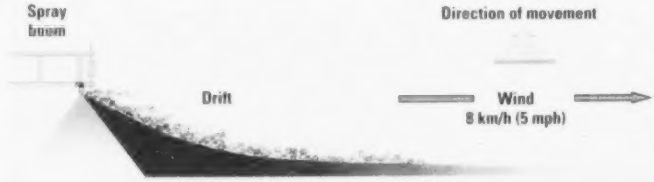
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APPLICATION

BEST MANAGEMENT PRACTICES

To do the job right, you need the right tool, and you have to keep that tool in proper working condition. Nothing could be more true for pesticide application equipment. It takes know-how to choose the right sprayer, nozzle, and accessories. And it takes prudence and a few tips to keep the equipment calibrated and working properly.

It pays to routinely maintain and calibrate your sprayer.

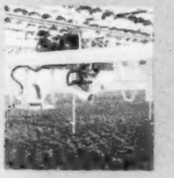
Properly selected and functioning application equipment will help you:

- ▸ know your precise rate of spray application (L/ha)
- ▸ hit the pest with the prescribed dose
- ▸ know you have the right output from the nozzle to do the job
- ▸ reduce product waste or leftovers (calibration)
- ▸ ensure that you get the droplet size to do the best possible job
- ▸ avoid off-target and off-site damage
- ▸ save time and money – fewer reapplications keep costs down!

EQUIPMENT TYPES

TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
HAND-OPERATED SPRAYERS 	• hand pumping compresses air, forcing the liquid mixture through the wand	• spot spraying small quantities (e.g., around trees) or spraying small areas • pressure regulators are now available to preset pressure + portable and convenient – pressures and outputs fluctuate – insufficient agitation of powders – need to stop and re-pressurize sprayer – physically demanding
HOSE-END SPRAYERS 	• vacuum from running water draws a fixed rate from a small spray bottle	• spot spraying lawns and gardens + may deliver 50 L of output before refilling – dirt in nozzle makes rates unreliable – accuracy is only fair at best – moderate to high risk for personal contamination – requires high water volume

APPLICATION

TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
BACKPACK SPRAYERS	• operate under pressure provided by small manual pump fitted into top or bottom of spray tank • hand-operated pump forces liquid out of the tank through hose and nozzle at pressures between 100-600 kPa (15-90 psi) • work better when pressure regulators are used – pressure regulators maintain uniform output	• hand-held (4-10 L capacity) or backpack (25 L capacity) • used for spot or limited area application (small orchard, nursery, rough areas) +preset inline pressure regulator available +no trampling of crop –pressure is variable –can drip –hard on shoulders –risk of personal contamination –hard to get into harness alone
MOTORIZED SPRAYERS	• a power-driven pump is used to provide pressure in the hose rather than the tank • could be boom, single-gun wands with 2-4 nozzles • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• mounted on tractors, trucks, trailers, aircraft • can be low- or high-pressure types • small-scale lawn and garden, hobby farmers, nursery and custom applications +portability –motor is dedicated to single use
BOOM SPRAYERS	• pump: centrifugal, piston, roller, diaphragm • PTO-driven • partial vacuum is created (except with centrifugal) in the suction line, which fills with spray from the tank • spray is forced through to the sprayer booms and nozzles • tanks are fitted with agitators to keep pesticide in suspension • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• used for row-crop pesticides +distributes pesticides uniformly over large areas +versatile – useful for many crops, pests and application techniques –nozzle-to-target distances will change with hills and valleys in fields
ULTRA-LOW-VOLUME SPRAYERS (ULV) 	• apply concentrates with very little or no water carrier • droplets contained by structure • smaller but more numerous droplets • rates: < 10 L/ha (< 1 gal./ac.)	• protected environment uses, e.g., greenhouse, cold storage +can be controlled remotely after hours +better coverage in protected environment –applicator at greater risk –few pesticides are registered for ULV –prone to drift

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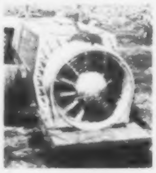
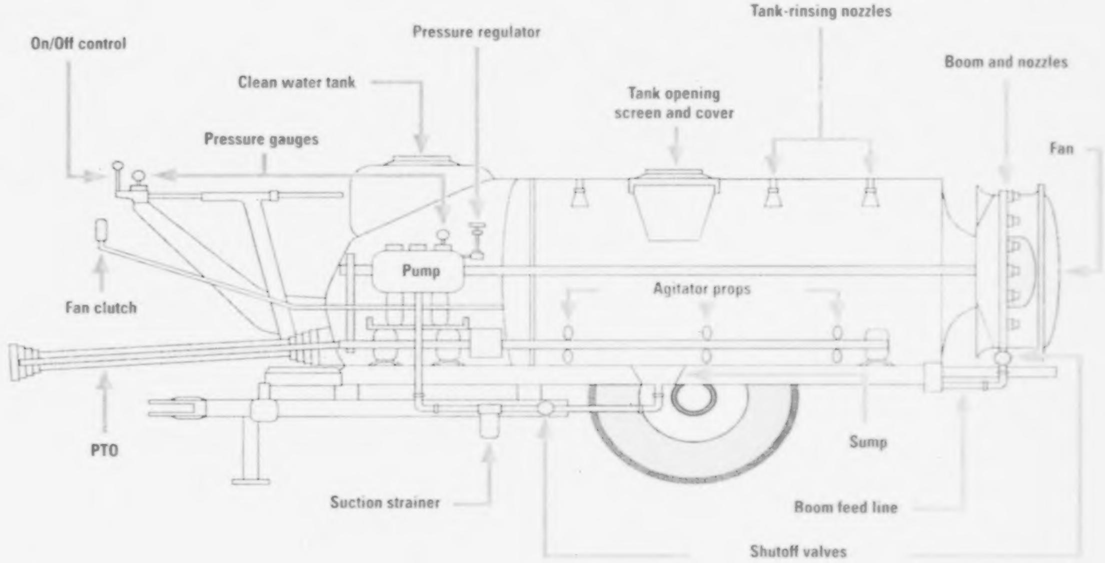
TYPE	HOW THEY WORK	USES (+ ADVANTAGES, – DISADVANTAGES)
ORCHARD SPRAYERS 	• air and liquid pressure used to deliver mix to target • pesticides pumped through nozzles into a blast of air from high-speed fan • fine droplets are carried to target • rates: 340-1000 L/ha (30-100 gal./ac.) • nozzles: ○ various types are available ○ flipover nozzles are available • pressure range: 500-2000 kPa (80-300 psi)	• used with tree fruit, cane fruit, and vineyard +high or low volume, range of pressures –mixture requires mechanical agitation –prone to drift problems
AIR-ASSIST BOOM SPRAYERS 	• similar to boom sprayers with addition of fan and manifold to deliver downward-moving air curtain • air is used to entrain small droplets and direct them towards target • rates: 50-500 L/ha (5-50 gal./ac.) • nozzles: 25-100 cm intervals (multi-nozzle holders available) • pressure range: 100-1500 kPa (15-215 psi) • booms: 6-40 m long (20-120 ft.)	• used for row-crop pesticides +will reduce off-field deposition +may increase canopy penetration but dependent on crop and stage of growth +direction of air curtain may be adjustable –high initial cost –air speed/volume infinitely variable (there can be problems determining air speed setting, especially with certain horticultural crops) –dust stirred up by forced air may affect pesticide efficacy


Tank-rinsing nozzles
On/Off control
Pressure regulator
Boom and nozzles
Clean water tank
Tank opening screen and cover
Pressure gauges
Fan
Pump
Agitator props
Fan clutch
PTO
Sump
Suction strainer
Boom feed line
Shutoff valves

Orchard sprayers project fine droplets to a target by pumping pesticide mixture through nozzles into a blast of air from a high-speed fan.

APPLICATION

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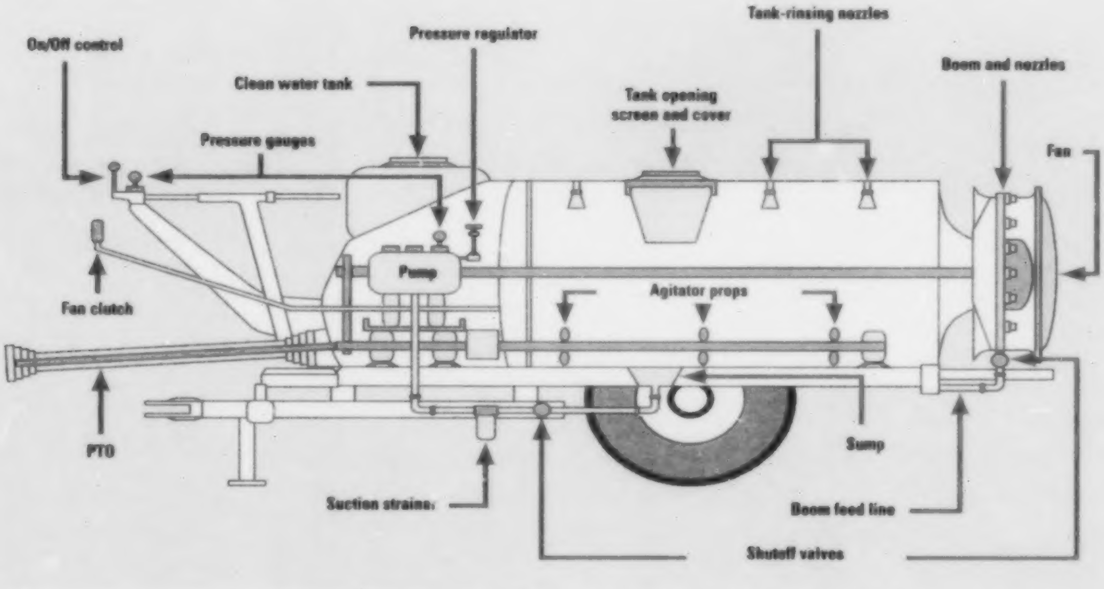
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APPLICATION

SPRAYER SELECTION

Choosing the best sprayer for the job takes careful planning. The following considerations should help you choose the most suitable equipment.

Crop types and acreage

- are you spraying row crops, vineyards, or orchards – or a combination?
- will you change your operation dramatically over the next 10 years, e.g., size of operation?
- will the sprayer work in all crop canopy stages, throughout the growing season?
- which types of materials are sprayed (herbicides, insecticides, fungicides)?
- how many different crops are planted?
- how often do you use the sprayer per season (e.g., each area once, 50% of the area 10 times)?
- are you matching sprayer capacity to acreage and available spray window?

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Sprayer capacity

- how rapidly can products be applied in case of emergency, e.g., severe crop loss due to insects or disease?
- how many tanks does it take to apply product to the most vulnerable crop?
- how much water per hectare is needed now and will be in the future?

In cases of emergency, sprayers have to be able to work effectively in both ideal and adverse conditions.

Performance in adverse conditions

- does the sprayer or related accessories allow spraying in higher winds without excessive drift (e.g., hooded booms, guide vanes, air-assist, etc.)?

Warranties and service

- are maintenance and repair easy?
- is expert assistance locally and readily available?
- are parts available and is the local dealer the only source?

Adaptability to other crops

- how adaptable is the sprayer (with or without accessories) to spray all crops?
  - advantages of having a second sprayer are less risk of injury and fewer rinsings per crop, e.g., herbicidal and insecticide sprayer

Choose a sprayer that's best suited and sized to the range of tasks in your operation.

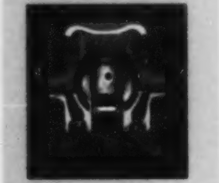
Sprayers should be easy to maintain and repair.

APPLICATION

All pumps should deliver the necessary flow rate required at the boom at the desired pressure, and have adequate flow to provide adequate agitation.

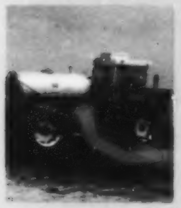
SPRAYER EQUIPMENT COMPONENTS

PUMPS

TYPE	FUNCTION	ADVANTAGES	DISADVANTAGES
ROLLER 	• small field/tractor-mounted sprayers • best for emulsifiable concentrates • soluble powders • up to 2000 kPa (300 psi) operating pressure	• low cost • self-priming • compact • easily rebuilt • wide range of sizes available	• mostly low volumes at low to moderate pressures • will wear quickly if wettable powders used • require regular maintenance • pulsation damper required • can be damaged by malfunctioning relief valve
CENTRIFUGAL 	• centrifugal force moves liquids from impeller to outlet; operating pressure up to 500 kPa (75 psi) ◦ multi-staged impellers can deliver higher operating pressures 1400 kPa (200 psi)	• durable, easy to repair, inexpensive • able to handle abrasive materials • only one moving part • high output • for constant pressure output, use pressure/regulator valve	• not self-priming • high-pressure centrifugal pumps are expensive to replace • sensitive to restrictions to inlet or to back pressure
PISTON 	• adaptable to many uses • operating pressure up to 3000 kPa (450 psi) • low to medium volumes/low to high pressures	• reliable, replaceable parts • output is a direct function of pump shaft speed • okay for abrasive materials	• most expensive • require surge chamber to reduce pulsations • large and heavy
DIAPHRAGM 	• high pressure • maximum operating pressure 3000 kPa (450 psi)	• will pump abrasive solutions • self-priming • diaphragms and check valves can be replaced • moving parts do not contact spray mixture	• require surge chamber to reduce pulsations • cost • replace all diaphragms at same time • bypass flow required when boom is shut off • large and heavy

APPLICATION

TANKS AND FITTINGS

TYPE	ADVANTAGES	DISADVANTAGES
MILD STEEL 	• low cost • easy to repair	• corrode and rust • short life • rust scale plugs equipment • right angle joints cause dead agitation areas in tank
STAINLESS-STEEL 	• little damage from spray mixtures • long life • surfaces are easier to clean	• costs more than steel • repair costs more than steel • right-angle joints cause dead agitation areas in tank • different grades of stainless-steel – some are susceptible to corrosion
PLASTICS 	• less damage from spray mixtures • rounded corners are easier to agitate • low weight • no scale/corrosion	• require more support from frame • cannot be field repaired

AGITATORS

Mechanical agitators have a central shaft with paddles to stir the spray suspension.

+ pump sized only for boom requirements

– agitator can't be shut off to prevent foaming

– shaft seal requires regular adjustment to prevent leakage

Hydraulic agitators have a series of nozzles or jets that force liquid inside the tank to stir and mix.

+ adjustable rate of agitation

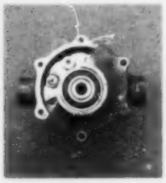
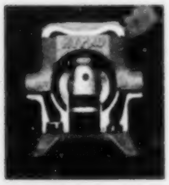
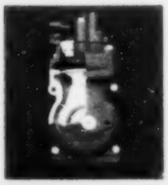
– requires larger pump

+ = advantage
– = disadvantage

All pumps should deliver the necessary flow rate required at the boom at the desired pressure, and have adequate flow to provide adequate agitation.

SPRAYER EQUIPMENT COMPONENTS

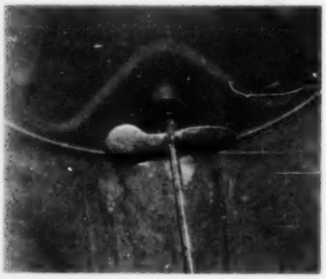
PUMPS

TYPE	FUNCTION	ADVANTAGES	DISADVANTAGES
ROLLER 	• small field/tractor-mounted sprayers • best for emulsifiable concentrates • soluble powders • up to 2000 kPa (300 psi) operating pressure	• low cost • self-priming • compact • easily rebuilt • wide range of sizes available	• mostly low volumes at low to moderate pressures • will wear quickly if wettable powders used • require regular maintenance • pulsation damper required • can be damaged by malfunctioning relief valve
CENTRIFUGAL 	• centrifugal force moves liquids from impeller to outlet; operating pressure up to 500 kPa (75 psi) ◦ multi-staged impellers can deliver higher operating pressures 1400 kPa (200 psi)	• durable, easy to repair, inexpensive • able to handle abrasive materials • only one moving part • high output • for constant pressure output, use pressure/regulator valve	• not self-priming • high-pressure centrifugal pumps are expensive to replace • sensitive to restrictions to inlet or to back pressure
PISTON 	• adaptable to many uses • operating pressure up to 3000 kPa (450 psi) • low to medium volumes/low to high pressures	• reliable, replaceable parts • output is a direct function of pump shaft speed • okay for abrasive materials	• most expensive • require surge chamber to reduce pulsations • large and heavy
DIAPHRAGM 	• high pressure • maximum operating pressure 3000 kPa (450 psi)	• will pump abrasive solutions • self-priming • diaphragms and check valves can be replaced • moving parts do not contact spray mixture	• require surge chamber to reduce pulsations • cost • replace all diaphragms at same time • bypass flow required when boom is shut off • large and heavy

TANKS AND FITTINGS

TYPE	ADVANTAGES	DISADVANTAGES
MILD STEEL 	• low cost • easy to repair	• corrode and rust • short life • rust scale plugs equipment • right angle joints cause dead agitation areas in tank
STAINLESS-STEEL 	• little damage from spray mixtures • long life • surfaces are easier to clean	• costs more than steel • repair costs more than steel • right-angle joints cause dead agitation areas in tank • different grades of stainless-steel – some are susceptible to corrosion
PLASTICS 	• less damage from spray mixtures • rounded corners are easier to agitate • low weight • no scale/corrosion	• require more support from frame • cannot be field repaired

AGITATORS



Mechanical agitators have a central shaft with paddles to stir the spray suspension.

+ pump sized only for boom requirements

– agitator can't be shut off to prevent foaming

– shaft seal requires regular adjustment to prevent leakage

Hydraulic agitators have a series of nozzles or jets that force liquid inside the tank to stir and mix.

+ adjustable rate of agitation

– requires larger pump

+ = advantage
– = disadvantage

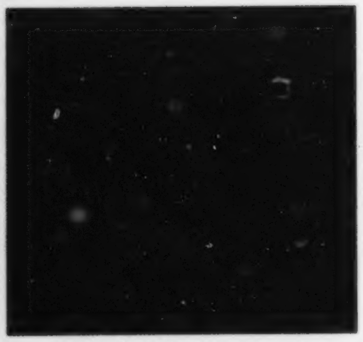
APPLICATION

NOZZLES

Pesticide efficacy partially depends on good application.

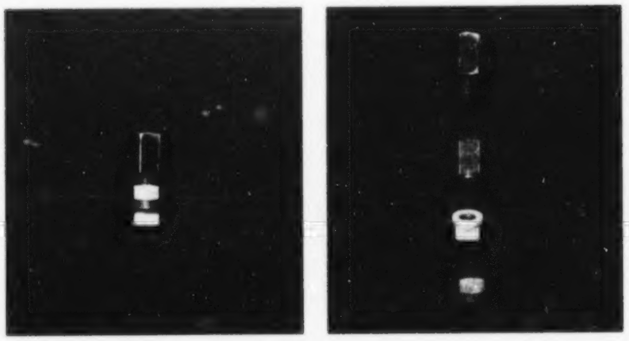
Spray nozzle and tip selection is an important decision, as nozzle type will affect three critical aspects of application:

- spray volume
- spray distribution on target
- droplet size.



The following screens are necessary to protect components and reduce plugging: tank-fill, suction, in-line (optional), and nozzle.

Note: Nozzle screens should be sized according to manufacturer's recommendations.

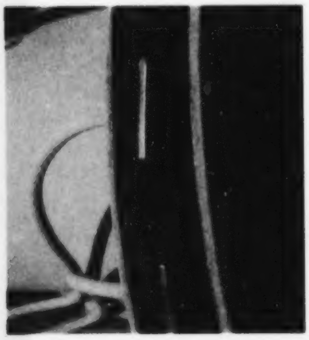


Most nozzles have four parts: body, screen, tip, and cap. Cone nozzles also have a swirl plate and orifice disc to regulate droplet size and meter the flow.

Note: Tips can be interchanged on a body made by the same manufacturer.

Spray nozzles come in four main families.

Solid-stream nozzles project a cylindrical stream over long distances. They're used for application of liquid fertilizer on crops.

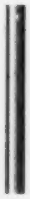
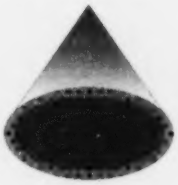
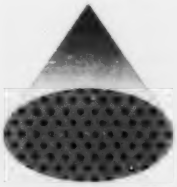


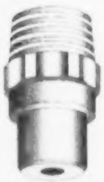
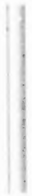
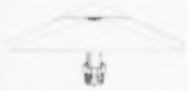
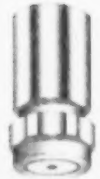
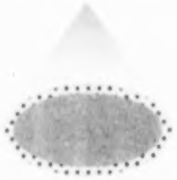
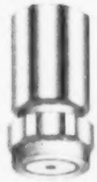
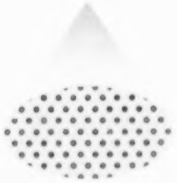
Air-shear nozzles project a sheet of liquid into high-speed air, shearing the sheet. They're used mostly with air-blast sprayers.

Cone or swirl nozzles are primarily for high-pressure application of insecticides, fungicides, and some multi-nozzle directed sprays.

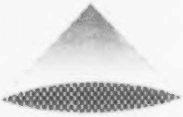
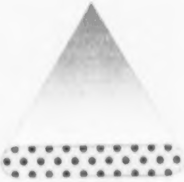
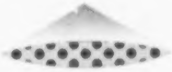
Flat fans are used for low-pressure application of pesticides with boom sprayers.

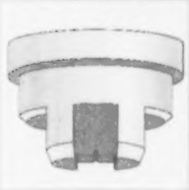
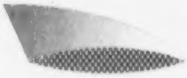
APPLICATION

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
SOLID-STREAM (PIN) 	• handguns – livestock, cylindrical stream • trees, nursery • liquid fertilizer • systemic pre-plant insecticides • roadside vegetation control	• round hole makes a stream that breaks into large droplets	• 140-1400 kPa (20-200 psi)	• mostly large 
AIR-SHEAR 	• air-blast orchard • horticultural crop spraying used on air-blast orchard sprayers	• high-speed air shears liquid sheet • finest droplets if sprayed into air stream	• 140 kPa (20 psi)	• variable – dependent on direction of air stream intersecting nozzle
HOLLOW CONE 	• horticultural crop spraying used with air-blast sprayers and on row crops • where canopy penetration is required • crop spraying of wettable powders, flowables, and suspensions	• round hole plus 1-4 hole swirl plate produces hollow cone spray • 60-100° spray angle	• 275-2070 kPa (40-300 psi)	• finer, more uniform droplet size than solid cone nozzles 
FULL CONE 	• horticultural crop spraying used on row crop and air-blast sprayers to apply fungicides and insecticides • better crop penetration	• centre hole in swirl plate fills cone	• 275-2070 kPa (40-300 psi)	• larger droplet size than hollow cone 

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
SOLID-STREAM (PIN) 	• handguns – livestock, cylindrical stream • trees, nursery • liquid fertilizer • systemic pre-plant insecticides • roadside vegetation control	• round hole makes a stream that breaks into large droplets	• 140-1400 kPa (20-200 psi)	• mostly large 
AIR-SHEAR 	• air-blast orchard • horticultural crop spraying used on air-blast orchard sprayers	• high-speed air shears liquid sheet • finest droplets if sprayed into air stream	• 140 kPa (20 psi)	• variable – dependent on direction of air stream intersecting nozzle
HOLLOW CONE 	• horticultural crop spraying used with air-blast sprayers and on row crops • where canopy penetration is required • crop spraying of wettable powders, flowables, and suspensions	• round hole plus 1-4 hole swirl plate produces hollow cone spray • 60-100° spray angle	• 275-2070 kPa (40-300 psi)	• finer, more uniform droplet size than solid cone nozzles 
FULL CONE 	• horticultural crop spraying used on row crop and air-blast sprayers to apply fungicides and insecticides • better crop penetration	• centre hole in swirl plate fills cone	• 275-2070 kPa (40-300 psi)	• larger droplet size than hollow cone 

APPLICATION

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
FLAT FAN (TAPERED) 	• broadcast herbicide and insecticide with booms • 30-100% overlap	• lens-shaped hole (with no swirl plate) • makes elliptical-shaped pattern tapered ends • pattern affected by spacing, height and angle • if lower pressure than recommended is used, spray patterns collapse – reducing spray angle and affecting distribution	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
EVEN FLAT FAN 	• banding of herbicides or insecticides in row crops	• oval hole makes rectangular pattern with sharp cutoff • available in variety of spray angles • boom height and nozzle spray angle will influence width of spray swath	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
FLOOD 	• broadcast spraying of pre-plant herbicides • wind-tolerant spray pattern • large self-propelled sprayers	• wide flat sprays 135° • tapered edge, flat fan pattern • wide spacing capability • older designs had heavy outer edges; improved versions eliminated these	• low pressures • 100-400 kPa (15-60 psi)	• large droplets 

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
OFF-CENTRE NOZZLES 	• short booms for non-crop areas • extend boom width ends to spray field edge or fence rows • spraying under crop canopy for inter-row coverage of soil surface	• wide, flat spray off to one side	• 100-400 kPa (15-60 psi) • same as flat fan	• majority of droplets fall in middle of a range from fine to coarse 

CHOOSING THE RIGHT NOZZLE FOR THE JOB

Choosing the right nozzle for the job takes careful consideration of:

- ▶ the target
- ▶ the product
- ▶ the nature of the nozzle
- ▶ environmental factors
- ▶ droplet size.

Product formulation (e.g., wettable powder) and mixtures may dictate nozzle type.

Pesticide product efficacy is based in part on timing and coverage.

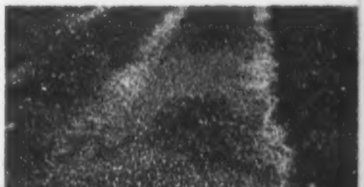
Mode of action is important. For example, systemic pesticides may not require the same extent of coverage as contact pesticides. However, locally systemic products do require better coverage for effective control.

Look at product labels for recommended volumes, pressures, nozzle types, angles, and spacing.

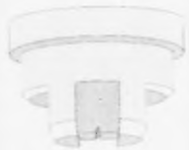
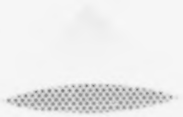
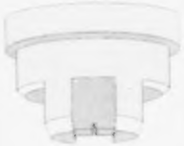
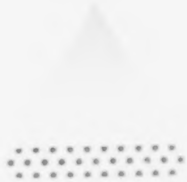
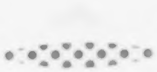
NOZZLE CONFIGURATION. Hitting the target may mean changing the configuration of nozzles (e.g., drop nozzle in ginseng for foliar disease control).

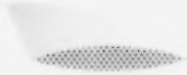
For dense canopy, solid cone nozzles (rather than hollow) may have to be used to compensate for denser canopy.

ROW CROPS. For pre-plant operation, the target is the soil surface. Use the nozzle that produces low pressure and large droplets. (Floods or flat fans would work.)



For post-emergence operations, the target is young weeds – some under the canopy or escapes. Use flat fan.

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
FLAT FAN (TAPERED) 	• broadcast herbicide and insecticide with booms • 30-100% overlap	• lens-shaped hole (with no swirl plate) • makes elliptical-shaped pattern tapered ends • pattern affected by spacing, height and angle • if lower pressure than recommended is used, spray patterns collapse – reducing spray angle and affecting distribution	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
EVEN FLAT FAN 	• banding of herbicides or insecticides in row crops	• oval hole makes rectangular pattern with sharp cutoff • available in variety of spray angles • boom height and nozzle spray angle will influence width of spray swath	• 100-400 kPa (15-60 psi)	• majority of droplets fall in middle of a range that varies from fine to coarse 
FLOOD 	• broadcast spraying of pre-plant herbicides • wind-tolerant spray pattern • large self-propelled sprayers	• wide flat sprays 135° • tapered edge, flat fan pattern • wide spacing capability • older designs had heavy outer edges; improved versions eliminated these	• low pressures • 100-400 kPa (15-60 psi)	• large droplets 

TYPE	USE	SPRAY PATTERN RANGE	OPERATING PRESSURE	DROPLET SPECTRUM
OFF-CENTRE NOZZLES 	• short booms for non-crop areas • extend boom width ends to spray field edge or fence rows • spraying under crop canopy for inter-row coverage of soil surface	• wide, flat spray off to one side	• 100-400 kPa (15-60 psi) • same as flat fan	• majority of droplets fall in middle of a range from fine to coarse 

CHOOSING THE RIGHT NOZZLE FOR THE JOB

Choosing the right nozzle for the job takes careful consideration of:

- the target
- the product
- the nature of the nozzle
- environmental factors
- droplet size.

Product formulation (e.g., wettable powder) and mixtures may dictate nozzle type.

Pesticide product efficacy is based in part on timing and coverage.

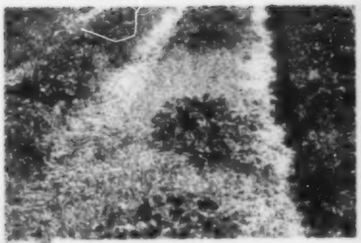
Mode of action is important. For example, systemic pesticides may not require the same extent of coverage as contact pesticides. However, locally systemic products do require better coverage for effective control.

Look at product labels for recommended volumes, pressures, nozzle types, angles, and spacing.

NOZZLE CONFIGURATION. Hitting the target may mean changing the configuration of nozzles (e.g., drop nozzle in ginseng for foliar disease control).

For dense canopy, solid cone nozzles (rather than hollow) may have to be used to compensate for denser canopy

ROW CROPS. For pre-plant operation, the target is the soil surface. Use the nozzle that produces low pressure and large droplets. (Floods or flat fans would work.)



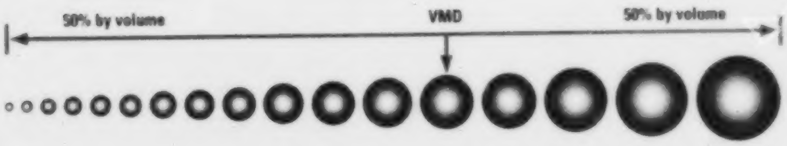
For post-emergence operations, the target is young weeds – some under the canopy or escapes. Use flat fan.

APPLICATION

The best source of help for **nozzle selection** is manufacturers' catalogues. See previous section for description of nozzle types.

NOZZLE MATERIAL	RELATIVE WEAR
• ceramic	• slow
• hardened stainless-steel • plastic • stainless-steel	• moderate
• nylon • steel • brass	• rapid

VOLUME MEAN DIAMETER (VMD)



The droplet spectrum is defined by the term Volume Mean Diameter. This is the diameter in the droplet spectrum in which half the volume is contained in smaller droplets and half in larger droplets.

Choose the nozzle that produces droplets that will hit the target, minimize drift, and produce the droplet size distribution to allow the product to do the job.

ENVIRONMENTAL FACTOR	BEST MANAGEMENT PRACTICE
WIND, HIGH TEMPERATURE, AND LOW RELATIVE HUMIDITY	• use drop nozzle sprays to reduce evaporation • use larger orifices at lower pressures • use wide angle at low boom heights • use high carrier volumes • use drift-reducing tips • minimize nozzle to target distance • don't spray if too windy or near sensitive crops, natural areas, or residential areas • delay application of volatile chemicals to when temperatures are cooler

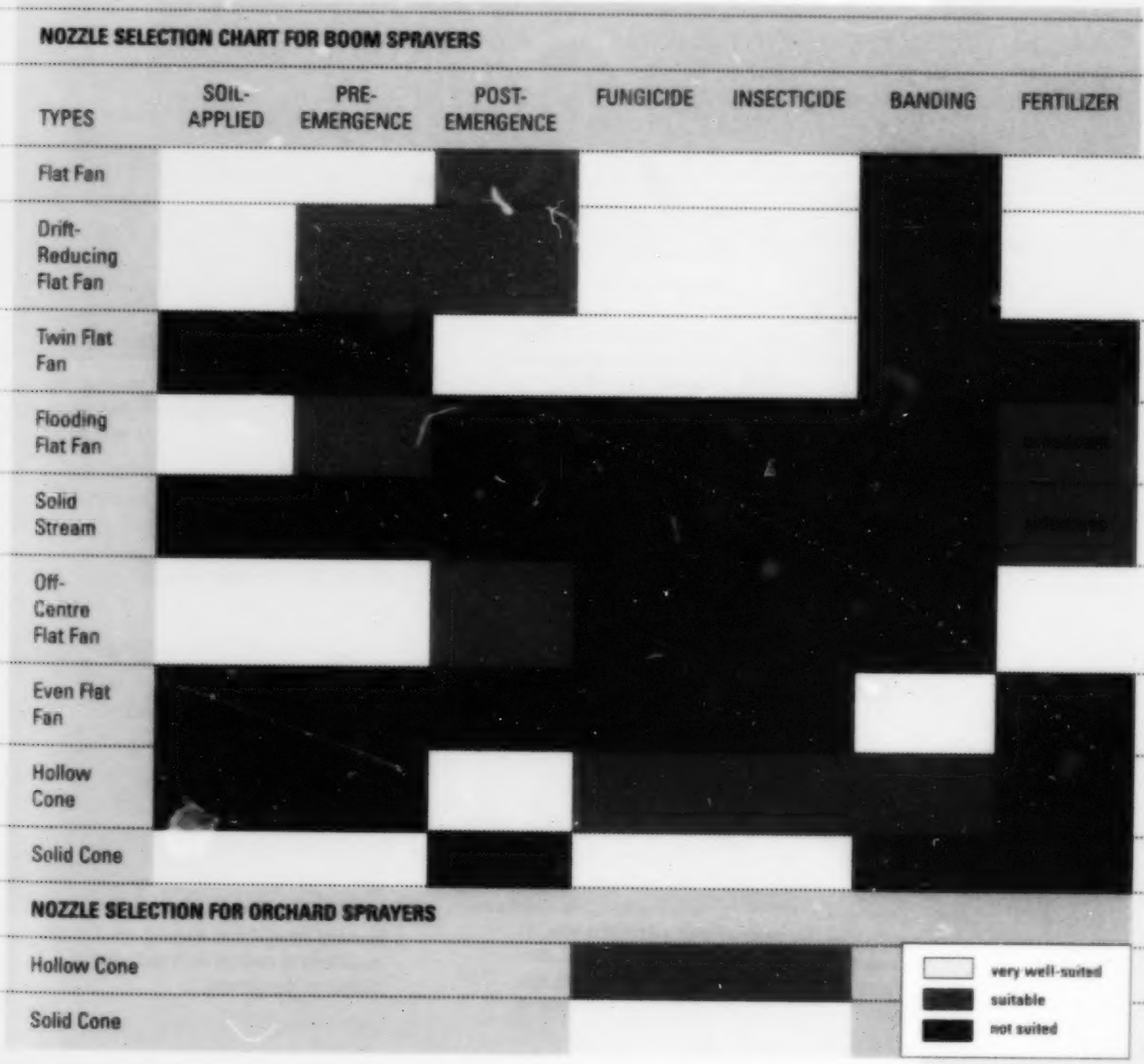
APPLICATION

'Tips' for Tips

A farmer decides to buy a new sprayer. The dealer has told the farmer that they will outfit the sprayer with one set of nozzles of the farmer's choice. The farmer would like to pick the best nozzle that will be capable of doing all spray jobs.

The reality is that one set of tips, and only one set of tips, will not do the best spraying job, when you take into account factors such as: water volumes, weather conditions, whether the product is a contact or systemic material, stage of development of the crop, plant structure, etc. As you delve deeper into nozzle selection, you will find that regardless of the nozzle type selected, it is always a compromise. A nozzle that produces droplets to give you adequate coverage may be very drift-prone.

In choosing a nozzle you have to determine the priority. Is it coverage, penetration, deposition, drift, or distribution pattern?


NOZZLE SELECTION CHART FOR BOOM SPRAYERS
TYPES
SOIL-APPLIED
PRE-EMERGENCE
POST-EMERGENCE
FUNGICIDE
INSECTICIDE
BANDING
FERTILIZER
Flat Fan
Drift-Reducing Flat Fan
Twin Flat Fan
Flooding Flat Fan
Solid Stream
Off-Centre Flat Fan
Even Flat Fan
Hollow Cone
Solid Cone
NOZZLE SELECTION FOR ORCHARD SPRAYERS
Hollow Cone
Solid Cone
very well-suited
suitable
not suited

The best source of help for **nozzle selection** is manufacturers' catalogues. See previous section for description of nozzle types.

NOZZLE MATERIAL	RELATIVE WEAR
• ceramic	• slow
• hardened stainless-steel • plastic • stainless-steel	• moderate
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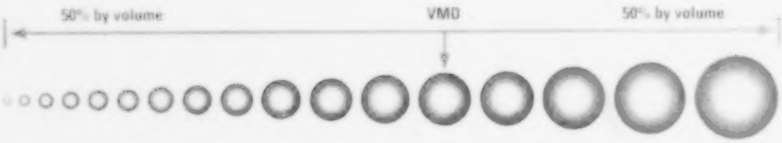
VOLUME MEAN DIAMETER (VMD)



The droplet spectrum is defined by the term Volume Mean Diameter. This is the diameter in the droplet spectrum in which half the volume is contained in smaller droplets and half in larger droplets.

Choose the nozzle that produces droplets that will hit the target, minimize drift, and produce the droplet size distribution to allow the product to do the job.

ENVIRONMENTAL FACTOR	BEST MANAGEMENT PRACTICE
WIND, HIGH TEMPERATURE, AND LOW RELATIVE HUMIDITY	• use drop nozzle sprays to reduce evaporation • use larger orifices at lower pressures • use wide angle at low boom heights • use high carrier volumes • use drift-reducing tips • minimize nozzle to target distance • don't spray if too windy or near sensitive crops, natural areas, or residential areas • delay application of volatile chemicals to when temperatures are cooler

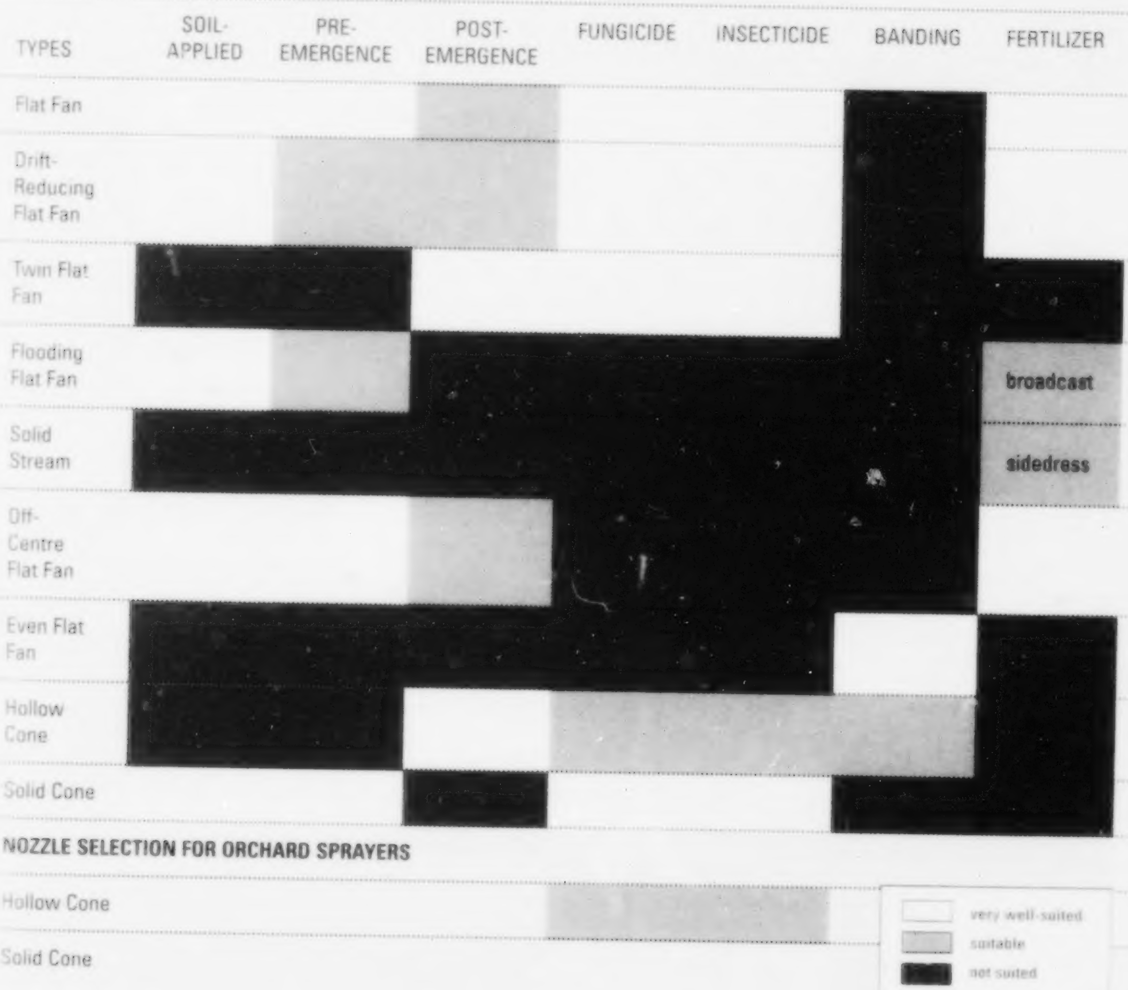
'Tips' for Tips

A farmer decides to buy a new sprayer. The dealer has told the farmer that they will outfit the sprayer with one set of nozzles of the farmer's choice. The farmer would like to pick the best nozzle that will be capable of doing all spray jobs.

The reality is that one set of tips, and only one set of tips, will not do the best spraying job, when you take into account factors such as: water volumes, weather conditions, whether the product is a contact or systemic material, stage of development of the crop, plant structure, etc. As you delve deeper into nozzle selection, you will find that regardless of the nozzle type selected, it is always a compromise. A nozzle that produces droplets to give you adequate coverage may be very drift-prone.

In choosing a nozzle you have to determine the priority. Is it coverage, penetration, deposition, drift, or distribution pattern?

NOZZLE SELECTION CHART FOR BOOM SPRAYERS



TYPES	SOIL-APPLIED	PRE-EMERGENCE	POST-EMERGENCE	FUNGICIDE	INSECTICIDE	BANDING	FERTILIZER
Flat Fan	⬜	⬜	▒	⬜	⬜	■	⬜
Drift-Reducing Flat Fan	⬜	▒	▒	⬜	⬜	■	⬜
Twin Flat Fan	■	■	⬜	⬜	⬜	■	■
Flooding Flat Fan	⬜	▒	■	■	■	■	▒ broadcast
Solid Stream	■	■	■	■	■	■	▒ sidedress
Off-Centre Flat Fan	⬜	⬜	▒	■	■	■	⬜
Even Flat Fan	■	■	■	■	■	⬜	■
Hollow Cone	■	■	⬜	▒	▒	▒	■
Solid Cone	⬜	⬜	■	⬜	⬜	■	■

NOZZLE SELECTION FOR ORCHARD SPRAYERS

TYPES	SOIL-APPLIED	PRE-EMERGENCE	POST-EMERGENCE	FUNGICIDE	INSECTICIDE	BANDING	FERTILIZER
Hollow Cone				▒	▒		
Solid Cone				⬜	⬜		

⬜ very well-suited
▒ suitable
■ not suited

APPLICATION

SPRAYER ACCESSORIES

Recent developments in sprayer accessories have resulted in more accurate application of pesticides to the target area, reduced the incidence of off-target contamination, and led to safer conditions for the pesticide applicator.

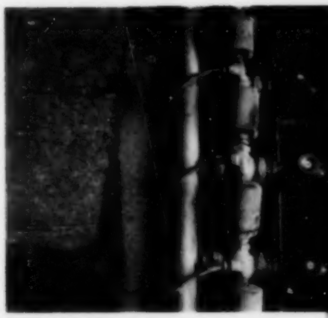
The photos below and on the next page depict some of the recent technology that's now available.

Self-regulating booms are used to keep a uniform distance between the nozzle and the target, even though the terrain undulates beneath the sprayer.

Nowadays, hydraulic wings can be individually raised and lowered according to the terrain. Previously, growers sometimes kept their booms too high to avoid getting too close to obstacles.

These swing booms have a mechanism for keeping the boom at an even height, even though the height of the tank may vary with a rough ride.

Rate controllers have become more popular in recent years. Used to show pressure and flow rate, and monitor spray volume, they can greatly improve sprayer accuracy.



Sonic orchard sprayers will shut on and off, depending on presence or absence of a tree.

Hooded sprayers and spray shields are available to reduce drift and provide selective placement.

APPLICATION

Global Positioning Systems (GPS) are finding their way into uses for pesticide applications, after proving their merit in applying fertilizer and mapping yields. By providing accurate field maps for weed infestation, growers can apply herbicides only where needed. This targets herbicide use to specific problem areas.

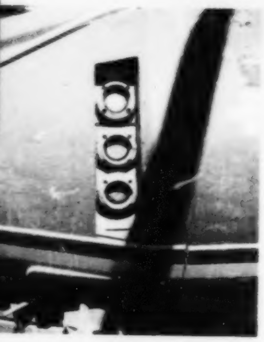
Air curtain sprayers have compartments of nozzles and hydraulic arms to reduce nozzle-to-target distances and attain better canopy penetration.

Recycling sprayers reduce drift and increase sprayer effectiveness by using walls and troughs to recycle spray mixture.

AI110015-VS
AI11002-VS
AI110025-VS
AI11003-VS
AI11004-VS
AI11005-VS

Air induction tips add air to reduce pressure and increase droplet size. They help reduce drift and increase coverage.

Vegetation-detecting sprayers are also available. Infra-red detectors can sense the presence of weeds. Nozzles turn on and off to spray sensed weeds.



This tree-sensing sprayer uses reflected light to sense orchard tree presence as it proceeds through the orchard.

APPLICATION

OTHER APPLICATION EQUIPMENT

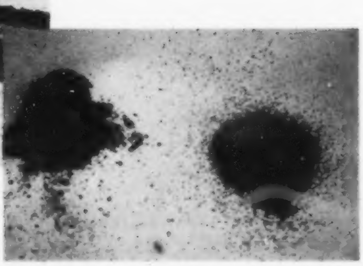
When using granular insecticides, ensure you:

- incorporate them into the soil to minimize exposure to birds
- clean up granule spills at the end of rows and in rough terrain
- use less toxic granular insecticides to reduce risk to birds.

Granular applicators are often used for field and vegetable crop application of insecticides. Multiple gravity-fed outlets and disc openers place product near seed. Proper applicators agitate the material and stop dispensing when forward motion stops. Poor application rates and broadcasting of granular pesticides pose direct health risks to beneficial wildlife – especially birds. Incorporation or banding granular is a best management practice.

Low-pressure fumigators are used to apply liquid, volatile soil fumigants. Water or soil is used to keep fumigants from vaporizing. Soil injection equipment places the fumigant 15-20 centimetres (6-8 in.) into the soil.

Special precautions are necessary to prevent volatile fumigants from escaping following application.



Birds often ingest soil materials to aid digestion. Granular insectides can be easily mistaken for soil materials. Therefore, choose those products that are less toxic to birds.

APPLICATION

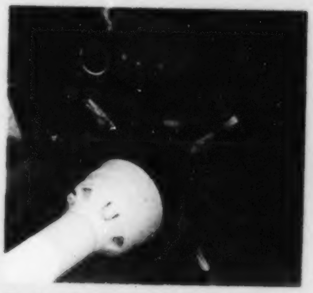
MAINTENANCE

Many problems encountered with the use of sprayer equipment can be prevented with planned, routine and seasonal maintenance. Here are some best management practices for maintaining field and orchard sprayers.

PUMP MAINTENANCE

WHAT TO DO	HOW TO DO IT
• flush the pump daily	• make sure tank is empty of pesticide mix • use clean water to rinse tank, booms, and nozzles daily • empty rinsate onto spray pad, or if mostly clean, use field
• lubricate pump	• follow manufacturer's guidelines • do it daily if grease or oil fittings provided • if oil pan/bath, check levels weekly • use recommended grades of oil/grease
• for a piston pump ◦ inspect check valves, valve seats, o-rings, seals, plunger cups, and cylinders	• inspect annually and replace if necessary • leading edge of cup should be sharp or mix will be trapped between cup and cylinder wall • operate pump with water and ensure no liquid is bypassing cups – do this for new cups or first time in spring
• for a diaphragm pump ◦ if pressure has dropped or reduction in flow evident, investigate	• disassemble pump • inspect all check valves and replace as necessary • annually check machine screws holding the diaphragm in place • replace all diaphragms – replace diaphragms annually as a preventative measure • reassemble
• for a centrifugal pump ◦ check for leaks ◦ check operating pressure ◦ never let pumps run dry ◦ drain all pumps before freeze-up or frost	• for leaks, replace shaft seals • replace seal – or if older model, tighten compression unit • prevent spray mixture from contacting shaft bearings – adjust slinger ring so that it's tight enough to rotate with shaft • drain tank, flush system with water – winterize pump with antifreeze

Flush the pump daily.



Drain all pumps before freeze-up or frost.

APPLICATION

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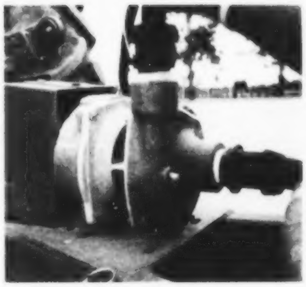

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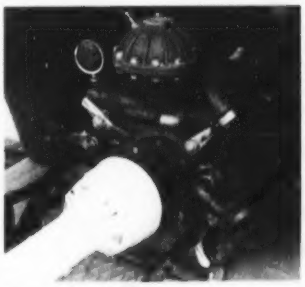


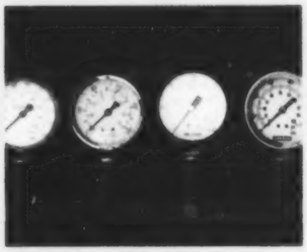
Drain all pumps before freeze-up or frost.

APPLICATION

Periodically disassemble pressure regulator to check internal components. Replace parts that show wear, e.g., plunger.

PRESSURE REGULATOR MAINTENANCE

WHAT TO DO	HOW TO DO IT
• lubricate • adjust packing	• follow manufacturer's recommendation • tighten or loosen to prevent malfunction ○ too tight – may allow dangerous pressure levels ○ too loose – leakage or chattering
• if you are not sure of the pressure for which the regulator is set	• slacken pressure before starting pump, then gradually readjust pressure



If gauge needle is bouncing, compare with a known working gauge. Check to see if your pulsation dampener is malfunctioning.

PRESSURE GAUGE MAINTENANCE

WHAT TO DO	HOW TO DO IT
• if the gauge is not functioning	• release in-line pressure • check for plugging from line to gauge • compare with a known working gauge • install a gauge isolator or replace with oil-filled gauge
• if you suspect that the gauge is inaccurate	• connect a new gauge in parallel • compare readings – replace if necessary

Inspect and clean the strainer early in season to ensure free flow of the pump.

STRAINER MAINTENANCE

WHAT TO DO	HOW TO DO IT
• check for tank scale • prevent buildup • clean screen	• inspect and clean early in season to ensure free flow to the pump • at the end of each growing season, rinse tank out thoroughly to flush out particulates • always put water and materials through screen to keep out debris, leaves and other contaminants • if butter-like deposit builds up, follow manufacturer's directions for suitable solvents
• if excessive deposits build up	• check with dealer to discuss chemical compatibility
• if strainer cracked or fits poorly	• replace it
• check nozzle strainer	• nozzle strainer should have a mesh finer than nozzle orifice • check manufacturer's catalogue

APPLICATION

NOZZLE MAINTENANCE

WHAT TO DO	HOW TO DO IT
• clean nozzle tips • replace worn tips	• use a soft-bristled (nozzle tip) brush • check nozzle output per minute to determine wear • use manufacturer's catalogue to match tips to proper nozzle body
• for swirl/cone nozzles	• check swirl plate and orifice disk
• check nozzle tips	• if caps are too tight, spray pattern is altered and may leak • replace washer if leaky

Use a soft-bristled brush to clean nozzle tips.

TANK MAINTENANCE

WHAT TO DO	HOW TO DO IT
• drain tank after use	• drain tank discharge line and sediment chamber, and NEVER LEAVE A TANK PARTLY FULL WITHOUT AGITATION • add clean water to the tank, circulate thoroughly, and spray out in treated field • leave hatch open to permit rapid drying

Drain tank after use.

AGITATOR MAINTENANCE

WHAT TO DO	HOW TO DO IT
• inspect mechanical agitator	• ensure paddles are secure on shaft • check lubricant of shaft bearing • check seals to prevent leakage • check integrity of agitator paddles and shaft • check drive belt, replace as necessary
• inspect hydraulic agitator	• check to see agitators are complete and providing visible liquid movement in tank • ensure pump capacity is sufficient for total nozzle output, plus flow to agitator and some overflow to maintain pressure • check orientation of agitators: they should spray diagonally into corners

Check agitator paddles and shafts for breakage and wear.

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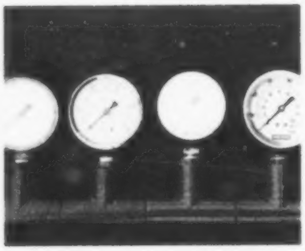

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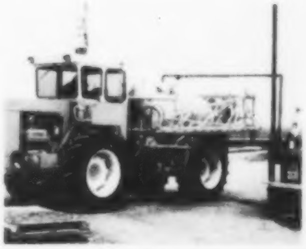

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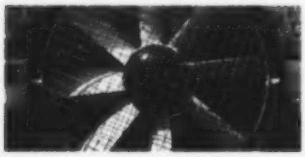
Prevent overheating by cleaning radiator.

Inspect belts regularly.



Keep fan blades clean.

MAINTENANCE FOR	WHAT TO DO	HOW TO DO IT
ENGINE	• prevent overheating	• clean radiator • lubricate, change oil and oil filter
BELTS	• inspect belts	• look for broken, separated, missing or worn belts • look for pulley wear • check belt tension • check idler operation
BLOWER UNIT	• keep fan blades clean	• wash or scrape off deposits – even a small buildup can cause problems
UNDERCARRIAGE	• check frame for cracks or broken welds	• reweld
	• check bolts	• tighten to recommended specifications
	• inspect wheel spindles	• look for signs of wear or fatigue

SPRAYER WINTERIZING CHECKLIST

☑ Fill sprayer tank with clean water and operate pump until only clear water is being discharged through the nozzle. This should be done on spray pad or other suitable containment system. See Handling section.

☑ Open the tank drain valve. Remove and clean suction strainer.

☑ Remove drain plugs from pump and tank. Lubricate pump as outlined by manufacturer. Fill pump with environmentally friendly antifreeze.

☑ Run sprayer for a few seconds to dislodge any water in valves and in lines.

☑ Drain the crankcase. Refill with new oil to prevent corrosion of bearing parts during storage. Check lubrication in speed reducer.

☑ Lubricate spray guns or spraying attachments.

☑ Check all hose connections and replace clamps, etc.

☑ Remove all dirt or corrosion and repaint if needed.

☑ Keep entire sprayer in building, under cover.

APPLICATION

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☑ Keep entire sprayer in building, under cover.

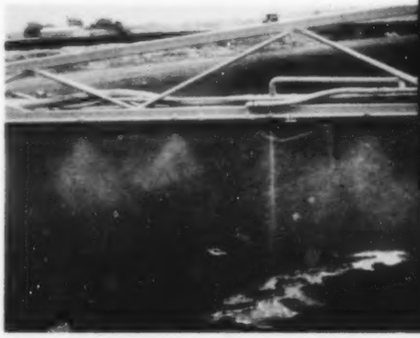
SPRAYER CALIBRATION

Most problems with pesticide application can be prevented if sprayers are properly calibrated. Poorly calibrated sprayers can be the cause of several problems.

PEST ESCAPES. Uneven application or improper dosage can miss a sufficient number of pests at key stages.

PESTICIDE RESIDUES. Inconsistent application rates may leave excessive residue levels on fruit and vegetable products.

POOR RETURNS. Expensive reapplication of pesticides together with losses in yield and quality can lower expected returns on high value crops.



CROP DAMAGE. Uneven nozzle output will deposit too much product on sensitive crops.

The **goals** of sprayer calibration are to:

- verify that all equipment components are functioning properly
- ensure that sprayer output and volume applied give you the recommended dosage
- accurately predict the number of tanks, trips, and total time of the application, but most importantly determine the amount of pesticide per tankful
    - 'recipe cards' – with all particulars (such as acres/tankful, acres to spray, product/ tankful) should be done in advance, then posted in pesticide storage building.

APPLICATION

BOOM SPRAYER

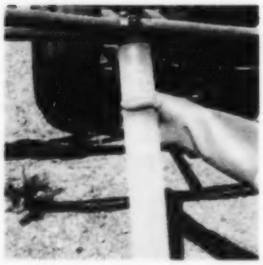
1. **Clean all components.**

2. **Fill sprayer one-half full of water only.**

3. **Record time for equipment to travel 50 metres:**
   - ▸ set up two stakes in the field to be sprayed
   - ▸ set throttle at desired application speed
   - ▸ do three runs of the 50 m course
   - ▸ average the time in seconds for the equipment to travel 50 m.

APPLICATION

4. Calibrate nozzles



- park sprayer
- use beaker or other graduated container to capture and measure the volume from each nozzle for the same time calculated in Step 3
- record volume collected on sprayer calibration sheet (see next page)
- divide the total output from all nozzles by the number of nozzles to determine average flow of one nozzle
- replace any nozzles that deviate more than 5% from average output or more than 10% from manufacturer's specifications

5. Calculate sprayer application rate (L/ha)

- measure the distances between nozzles (m)
- multiply the average nozzle output by factor 0.2 and divide by the nozzle spacing in metres (see sprayer calibration sheet).

$$\text{Sprayer Application Rate} = \frac{\text{Average Output (ml)} \times 0.2}{\text{Nozzle Spacing (m)}}$$
$$\text{L/ha}$$

6. Determine the number of tanks to spray field

- note sprayer capacity in litres
- measure the length and width of your field
- multiply length by width to calculate area of field
- the application rate calculated is based on L/ha – you'll need to determine hectares
- multiply area by application rate to determine total volume (L) for the field
- divide total volume (L) by sprayer capacity (L) to determine number of tanks required to spray field

SPRAYER CALIBRATION SHEET

Tractor: ____________________

Gear: ____________________

Engine RPM: ____________________

Nozzles: Type: ______________

Age: ______________

Spacing (m): ________

Height (m): ________

Pressure: ________

Pump Type: ______________

Model: ______________

Tank Size: ______________ litres

Time Over 50 Metres: ______________ seconds

Average Time: ______________ seconds

Nozzle No. and Volume Collected for Each Nozzle (ml)

1 ________ 11 ________ 21 ________ 31 ________ 41 ________
2 ________ 12 ________ 22 ________ 32 ________ 42 ________
3 ________ 13 ________ 23 ________ 33 ________ 43 ________
4 ________ 14 ________ 24 ________ 34 ________ 44 ________
5 ________ 15 ________ 25 ________ 35 ________ 45 ________
6 ________ 16 ________ 26 ________ 36 ________ 46 ________
7 ________ 17 ________ 27 ________ 37 ________ 47 ________
8 ________ 18 ________ 28 ________ 38 ________ 48 ________
9 ________ 19 ________ 29 ________ 39 ________ 49 ________
10 ________ 20 ________ 30 ________ 40 ________ 50 ________

Total All Nozzles: ____________ ml

Average Per Nozzle: ____________ ml

Application Rate (L/ha)

$$= \frac{\text{Average Output Per Nozzle (ml)}}{\text{Nozzle Spacing (m)}} \times 0.2$$

$$= \frac{\underline{\qquad\qquad\qquad} \text{(ml)}}{\text{(m)}} \times 0.2$$

$$= \underline{\qquad\qquad\qquad} \text{L/ha}$$

Number of Tanks Required to Spray Field

$$= \frac{\text{Application Rate (L/ha)} \times \text{Area (ha)}}{\text{Sprayer Capacity (L/tank)}}$$

N.B. If you wish to convert to units other than L/ha, use conversion factors in margin after you've completed calibration sheet.

Conversion Factors

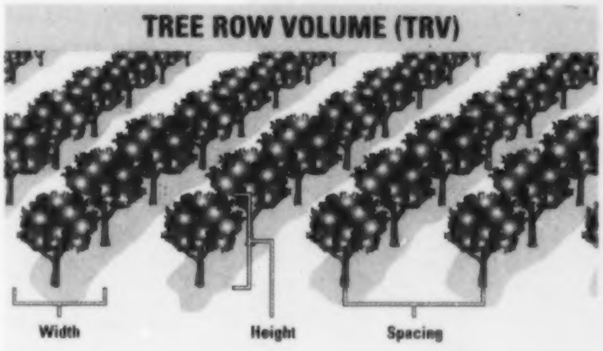
L/ha x 0.09 = Imperial gallons/acre

L/ha x 0.11 = U.S. gallons/acre

U.S. gallons x 3.785 = litres

Imperial gallons x 4.54 = litres

HOW TO CALIBRATE YOUR ORCHARD SPRAYER



1. Calculate tree row volume (TRV)

- unlike fields, you have to spray a series of rectangular-shaped rows to maximize coverage of orchard trees and minimize wasted spray on alleys between rows
- TRV is an estimate of the volume of tree foliage in an orchard
- to determine TRV you need to know:
  - tree height in metres
  - tree width in metres (drip line)
  - spacing between rows in metres
- calculate TRV
  - TRV (m^3/ha) = Tree Height (m) x Tree Width (m) x 10,000 (m^2/ha) / Spacing Between Rows (m)

$$\text{TRV } (m^3/ha) = \frac{\text{Tree Height (m)} \times \text{Tree Width (m)} \times 10{,}000\ (m^2/ha)}{\text{Spacing Between Rows (m)}}$$

$$\text{TRV } (m^3/ha) = \frac{\_\_(m) \times \_\_(m) \times 10{,}000\ (m^2/ha)}{\_\_(m)}$$

$$= \_\_\_\_\_\_\_\_\_\_\ m^3/ha$$

2. Calculate the spray volume per hectare needed to effectively apply a pesticide to your site

- spray volume required (L/ha) = TRV (m^3/ha) [from Step 1] x 0.028 (L/m^3) [a constant]

= __________ (m^3/ha) x 0.028 (L/m^3)

= __________ (L/ha)

3. Determine the spray volume rate/side (L/min./side)

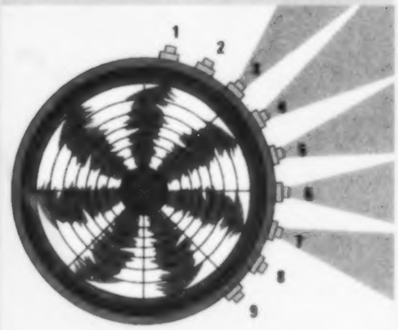
- note your target travel speed
- put your spray volume rate required (Step 2), spacing between rows, and travel speed into the following formula:

$$\text{L/min./side} = \frac{\text{L/ha} \times \text{Spacing Between Row (m)} \times \text{Travel Speed (km/h)}}{\text{1200 (a constant)}}$$

$$\text{L/min./side} = \frac{\_\_(L/ha) \times \_\_(m) \times \_\_(km/h)}{1200}$$

Unlike fields, you have to spray a series of rectangular-shaped rows to maximize coverage of orchard trees and minimize wasted spray on alleys between rows.

NOZZLE CONFIGURATION



This illustration explains the worksheet example on the right. Nozzle positions 1-2 and 8-9 are not used (OFF) so that the orchard sprayer output will be be better directed at the target tree canopy.

Output from the remaining nozzle positions 3-7 should have a distribution as shown in the illustration on page 89, where most of the distribution comes from the central nozzle positions (3-5).

In this example, this distribution is best approximated if the nozzle locations have the following proportion of the ouput:

Nozzle position 3 – 15% of total

Nozzle position 4 – 20% of total

Nozzle position 5 – 30% of total

Nozzle position 6 – 20% of total

Nozzle position 7 – 15% of total.

To achieve this distribution, refer to Step 4.

4. Select and set up nozzles (top to bottom) for the spray volume rate per side determined in Step 3

- ▶ determine the number of nozzles per side
  - ▷ for small trees, block off the nozzles that miss the target
- ▶ determine average output per nozzle by dividing output per side by total number of nozzles to be used

$$\text{Avg. Output/Nozzle} = \frac{\text{Spray Volume Rate/side}}{\text{No. of Nozzles}} = \text{L/min.}$$

- ▶ use a sprayer nozzle output chart that comes with the sprayer to choose nozzles at each position at a selected pressure (e.g., 175 psi)
- ▶ adjust the nozzle selection so that a larger portion of the output is emitted from the centre nozzles of the sprayer (e.g., nozzle positions 4-6), and choose nozzles with progressively smaller outputs as you move away from the centre position to the top and bottom of the nozzle bank (e.g., nozzle positions 3 and 7)
- ▶ total all nozzles to compare output with what you calculate your need to be (compare with Step 3)
- ▶ you still need to run the machine for a period of time and then refill to see if it is putting out what it was set up for.

TRV WORKSHEET EXAMPLE for Spray Volume Rate of 17.5 L/min./side using Spraying Systems Nozzles

NOZZLE POSITION	DISC NO.	SWIRL NO.	L/MIN
1 OFF	D	–	
2 OFF	D	–	
3	D 4	– 45	2.77
4	D 5	– 45	3.50
5	D 6	– 45	4.71
6	D 5	– 45	3.50
7	D 4	– 45	2.77
8 OFF	D	–	
9 OFF	D	–	

TOTAL = 17.25 L/min./side @ 175 psi

5. Calculate the Tree Row Volume (TRV) chemical rate required per hectare

a) calculate TRV percentage based on a standard orchard (estimated at 35,191 m³/ha)

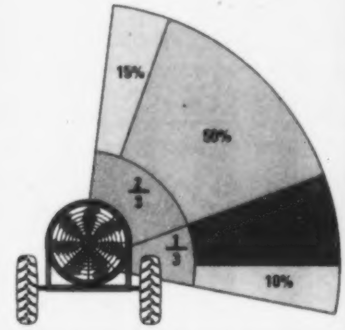
$$\text{TRV \%} = \frac{\text{Your TRV m}^3\text{/ha [Step 1] x 100}}{35{,}191 \text{ m}^3\text{/ha}}$$

$$= \frac{\_\_\_\_\_\_ \text{ m}^3\text{/ha x 100}}{35{,}191 \text{ m}^3\text{/ha}}$$

b) now, calculate TRV chemical rate required per hectare

$$\text{TRV chemical rate/ha} = \frac{\_\_ \text{ Label Rate/ha x } \_\_ \text{ TRV\% (Step 5a)}}{100}$$

$$= \_\_\_\_ \text{ Chemical Rate/ha}$$



Adjust the nozzle selection so that a larger portion of the output is emitted from the centre nozzles of the sprayer. Choose nozzles with progressively smaller outputs as you move away from the centre position to the top and bottom of the nozzle bank.

6. Number of hectares per tank

$$\text{Hectares/tank} = \frac{\text{Spray Tank Volume}}{\text{TRV Spray Volume Required [from Step 2]}}$$

$$= \frac{\_\_\_\_\_ \text{ L/tank}}{\text{L/ha}}$$

$$= \_\_\_\_\_ \text{ ha/tank}$$

7. Calculate amount of chemical per tank

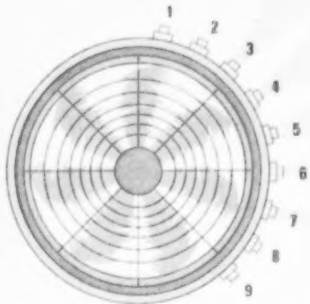
$$\text{Chemical/tank} = \text{Hectares/tank [Step 6] x Chemical Rate/ha [Step 5b]}$$

$$= \_\_\_\_\_\_\_ \text{ ha/tank x } \_\_\_\_\_\_ \text{ Chemical Rate/ha}$$

$$= \_\_\_\_\_\_\_ \text{ Chemical Rate/tank (e.g., L or kg)}$$

- ▶ agricultural chemical suppliers cannot be held liable for failure due to the use of rates below those recommended on their labels
  - ▷ do not use TRV considerations if a label indicates doing so is inappropriate
- ▶ water volumes of less than 300 L/ha are considered inadequate if there is fruit to protect
  - ▷ the lower the volume of spray, the more critical the accuracy of rates become
- ▶ remember, TRV serves as a guide for calibration
  - ▷ recognize that as the trees grow in height or width and the canopy density increases throughout the season, the amount of water and pesticide required will need to be adjusted
- ▶ higher volume sprays can be important to control some pests
  - ▷ increased pest pressure and past experiences may also influence the actual amount applied
- ▶ accurate calculation of TRV will not compensate for poor coverage, timing, chemical choice, or weather conditions

NOZZLE CONFIGURATION



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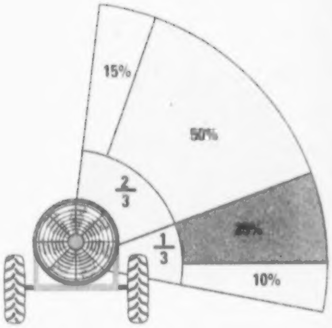

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$$= \frac{\underline{\quad\quad} \text{ L/tank}}{\text{L/ha}}$$

$$= \underline{\quad\quad} \text{ ha/tank}$$

7. Calculate amount of chemical per tank

Chemical/tank = Hectares/tank [Step 6] x Chemical Rate/ha [Step 5b]

= ________ ha/tank x _______ Chemical Rate/ha

= ________ Chemical Rate/tank (e.g., L or kg)

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APPLICATION

Prevent resistance – employ IPM practices.

Spray when temperatures range from 15°-25°C.

Explore new technologies to increase application efficiency and effectiveness.

CHECKLIST FOR APPLICATION BEST MANAGEMENT PRACTICES

☑ Employ integrated pest management (IPM) principles before selecting pest control methods: identify, monitor, and determine critical pest and economic thresholds.

☑ Read the label before making application.

☑ Avoid pest resistance by practising IPM and pest product rotation.

☑ Leave at least 15-metre buffer strips between your treatment and sensitive areas.

☑ Use proper water volume rates to ensure coverage and reduced drift. Check the pH of your water – extremely high or low pH can be a problem for some pesticides.

☑ Use adjuvants where stated on the label.

☑ Select nozzles to attain the droplet size spectrum that will bring about proper coverage and drift reduction.

☑ Verify nozzle output. Clean plugged nozzles. Replace worn and damaged nozzles.

☑ Adjust nozzle to target distance to minimize drift and maximize coverage.

☑ Maintain and adjust your sprayer regularly.

☑ Calibrate your application equipment before using it, and throughout the season.

☑ Weather: consider wind, humidity, temperature and rainfall events before application. Adjust application practices accordingly.

☑ Spray when temperatures range between 15-25°C and favour pest susceptibility. Avoid temperature extremes. Do not spray heat- or drought-stressed crops.

☑ Consider nozzles that have coarse droplet spectrums during periods of low humidity.

☑ Generally, don't spray insecticides or fungicides if rain is predicted and when drying conditions are poor. Washed off pesticides can cause off-site damage. Reapplication is expensive.

☑ Don't spray with conventional equipment during wind speeds greater than 10 km/hr if you select a fine mist spray output. It may be tolerable to spray in winds up to 20 km/hr if the spray droplets are mostly large, and if there are adequate buffer zones around sensitive and residential areas to prevent off-site damage, and if best management practices are used to reduce drift.

☑ Track your spray distribution. Use techniques such as water-sensitive paper near sensitive areas or visual evaluation of off-target areas. Know the fate of your spray – for personal safety, crop safety, and environmental protection. Keep accurate and detailed spray records for future reference.

☑ Explore new technologies to increase application efficiency and effectiveness.

APPLICATION

TROUBLESHOOTING KEY

PROBLEM	CAUSE	SOLUTION
MECHANICAL MAINTENANCE AND FAILURE		
SPRAY TANK EMPTIES ON ITS OWN	• sprayer contents backflow into water source • drain valve open, missing or damaged	• install anti-backflow device • replace drain valve
CANNOT PUMP OUT LAST 200 L IN TANK	• flow restrictor missing • pressure relief allowing bypass into tank	• install correct size orifice in agitator line • adjust flow to agitator nozzles
SPRAY SOLUTION LEFT OVER IN TANK	• travel speed too fast • wrong gear • wrong field dimensions • wrong set of tips • plugged nozzles • plugged line • dirty screens/filters	• slow down/recalibrate • check gear recommendations • check field dimensions • calibrate • clean nozzle tips • flush lines • check and inspect filters
PUMP GEARBOXES DAMAGED	• turning PTO off/on to turn sprayer off/on	• turn sprayer off using sprayer controls
BREAKAGE OF BOOMS	• self-regulating boom pinned solid • excessive travel speed • boom too low	• remove pin on self-regulating boom – unless only one side of boom is used • reduce travel speed • consider boom suspension system
FOAMING IN TANK	• agitation nozzles are above level of liquid • mechanical agitation too aggressive • product formulation • agitation inducing air into solution • low pH water	• reduce or shut off flow to agitators • investigate shutting off or reducing speed of agitators • read product label • investigate other product options or use of anti-foaming adjuvants • reduce or turn off agitation • buffer pH
SPILL ON ROADSIDE	• drain valve missing • pump left on • lid not secure • bottom valve not fully closed • broken fitting • tank perforated	• use personal safety procedures • contain spill • restrict source • replace drain valve, turn off pump, secure lid, close bottom valve, fix broken fitting • report spill • clean up spill

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APPLICATION

PROBLEM	CAUSE	SOLUTION
MECHANICAL MAINTENANCE AND FAILURE (cont'd.)		
LOSS OF PRESSURE **Hoses and fittings must be corrosion-resistant and able to withstand pressures or collapse.**	• pressure regulator improperly adjusted or stuck open	• clean and adjust pressure regulator
	• suction screen plugged	• thoroughly clean screen
	• cracked, collapsed, or porous suction hose	• replace hose
	• worn pump	• replace or recondition pump according to manufacturer's instructions
	• agitator nozzles blown off	• ensure agitation nozzles in place
	• worn nozzle tips	• replace nozzle tips
	• faulty gauge	• replace gauge
	• pump starving	• check for collapsed suction hose, plugged filter, main control valve too small or wrong type • check to see that anti-vortex fitting is in place in tank bottom
EXCESSIVE PRESSURE	• pressure regulator improperly set or stuck	• adjust pressure regulator
	• pressure line plugged or constricted	• unplug the hose or replace it
	• bypass hose plugged or too small	
	• faulty gauge	• replace gauge
NOZZLES AND OUTPUT		
DURING CALIBRATION, OUTER BOOM NOZZLES HAVE 10% LESS OUTPUT **The wrong nozzles for the task at hand can reduce output.**	• incorrrect nozzles	• calibrate or replace • check matching fittings both sides of sprayer
	• flow restriction	• use drill to increase internal diameter of fitting
	• partially plugged lines	• check boom line for blockage • flush out lines
	• partially plugged line filter	• clean line filters

APPLICATION

PROBLEM	**CAUSE**	**SOLUTION**
NOZZLES AND OUTPUT (cont'd.)		
SLUDGE IN TANK	• poor agitation • overagitation • poor tank cleaning practices • incompatible mixture	• check to see that agitator nozzles are working • read the label
UNEVEN SPRAY PATTERN **This uneven spray pattern was caused by improper boom height. Adjust boom height to attain proper overlap.**	• nozzle screen plugged • nozzle tip damaged • pressure too low • nozzles too small, worn or damaged • mismatched nozzles in boom • boom too low • uneven terrain	• clean or replace screen • replace tip with new one • check pressure on boom end with a gauge ○ pressure should be within 10 to 15 kPa of main gauge – if not, check size of fittings and hoses for restrictions • replace nozzles • raise boom or rotate ahead or back slightly • slow down, install boom wheel, readjust directional vanes (orchard air-blast)
PULSING SPRAY OUTPUT	• waterlogged pressure accumulator • diaphragm ruptured in pulsation dampener	• drain pressure accumulator or fix leak • replace diaphragm
SPRAY NOT REACHING TARGET	• spray too fine • boom set too high (row crops) • carrier airstream improperly directed • too windy • canopy interference	• reduce spray pressure, use larger nozzles • lower boom and angle forward or back • readjust directional fans • quit spraying • change nozzle type or nozzle placements
NO OUTPUT **No output can be caused by plugged main filter screens. Clean or maintain routinely.**	• frogs (or other wildlife) trapped in suction strainer • plugged lines • suction line shutoff valve is closed • suction intake in tank plugged • cracked suction lines • collapsed suction line to pump • pump malfunction • tank is empty	• flush lines • unplug • check tank and screens • replace with crush-proof pesticide compatible line • check pump intake • improper winterizing – check for cracks • check calculations • calibrate and check field dimensions

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NOZZLES AND OUTPUT (cont'd.)		
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	• nozzles too small, worn or damaged • mismatched nozzles in boom	• replace nozzles
	• boom too low	• raise boom or rotate ahead or back slightly
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	• pump malfunction	• check calculations
	• tank is empty	• calibrate and check field dimensions

APPLICATION

PROBLEM	**CAUSE**	**SOLUTION**
MONITORING		
CROP DAMAGE INCREASES AS YOU PROCEED DOWN THE FIELD	• ineffective agitation • soluble package dissolves too slowly	• check agitation equipment; don't use bypass line for agitation • review product mixing instructions
PHYTOTOXICITY	• improper product selection • dosage too high • improper tank mixes • timing of application • temperature, humidity, sunlight • equipment malfunction • crop development	• follow label directions • follow label directions and calibrate • follow label directions • spray in morning or evening – follow label products • follow label directions for conditions • check pump, pressure, nozzle output • read label and follow instructions
CROP INJURY IN STRIPS PARALLEL TO SPRAYER TRAVEL	• excessive overlapping • oversized nozzle tip(s) • excessive nozzle wear • nozzle to target distance	• use tram lines • replace and calibrate nozzles as required • check and follow manufacturer's recommended nozzle-to-target distances
WEED ESCAPES IN CORNERS	• underapplication of pesticides	• don't spray around the corner • back into corner, then start spraying
LACK OF CONTROL	• excessive travel speed • poor mixing • improper pesticide choice • pesticide resistance • excessive operating pressure • blocked screen • wrong stage of development	• calibrate and reduce speed • ensure adequate uniform agitation • check label • rotate chemical family • check label, re-evaluate nozzle choice and operating pressure • check screen and clean • diagnose pest problems more accurately
OFF-TARGET PROBLEMS	• high winds • small droplets • excessive spray	• nozzle selection • calibration • if windy, refrain from spraying • hooded sprayers

APPLICATION

PROBLEM	**CAUSE**	**SOLUTION**
MONITORING (cont'd.)		
PEST ESCAPES IN TOP INSIDE OF FRUIT TREES	• improper dosage • excessive canopy growth obstructs deposition • water volume too low • improper nozzle configuration • poor timing	• follow label directions • prune for better penetration • increase water volume, monitor prior to application • re-nozzle or reconfigure nozzles • monitor prior to application
NO WEED CONTROL IN WHEEL TRACKS	• spray not adhering to weeds • settling dust is deactivating spray	• use recommended adjuvant • don't spray when soil is pulverized
WEED ESCAPES IN STRIPS PARALLEL TO SPRAYER TRAVEL **Unharvested strips in this field are evidence that the producer didn't get full coverage of this field when applying herbicides.**	• plugged nozzles • worn or broken nozzles • travel too wide between swaths • nozzle-to-target distance (improper nozzle overlap) • sprayer not calibrated • canopy deflects spray	• replace worn or broken nozzles • use proper foam markers • use boom width as multiple of planter width • use tramlines • check manufacturer's recommendations • investigate front-mounted booms
RANDOM PATTERNS OF ESCAPES	• rate controller malfunctions • pressure too low • uneven terrain • product not fully dissolved	• investigate, repair as required • check pressure at boom end with gauge • re-evaluate travel speed • consider gauge wheels to improve boom heights • ensure good mixing
PLANTED CROP DOES NOT GERMINATE	• carryover from previous crop • poor sprayer cleanout	• keep accurate records • study product labels • check cleanout recommendations on label
EXCESSIVE RESIDUES IN HORTICULTURAL CROPS	• excessive dosage • interval to harvest too short • crop structure influences spray deposition	• read label – follow recommended rates • increase interval to harvest • reconfigure nozzle arrangement and volume • monitor deposition patterns

APPLICATION

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APPLICATION

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MONITORING (cont'd.)		
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	• interval to harvest too short	• increase interval to harvest
	• crop structure influences spray deposition	• reconfigure nozzle arrangement and volume
		• monitor deposition patterns

Backsiphoning

In an effort to fill his sprayer more quickly, a farmer decides to use a PTO-driven roller pump, in addition to the garden hose. With just the garden hose, the fill time is 45 minutes. With the addition of the roller pump powered by the second tractor, this time is reduced to 20 minutes. The garden hose is supplied from the house pressure system sourced from a deep drilled well. The roller pump is drawing from a dug well. The farmer fills the sprayer just before lunch. He decides to have lunch before he heads to the field. When he finishes lunch, he goes out and finds the sprayer empty. There's no water on the ground. The line from the roller pump is still in the tank.

The water in the sprayer has siphoned back into the well because no anti-backsiphoning device was installed. Luckily there was only water in the sprayer.

DETERMINING PESTICIDE EFFECTIVENESS

HOW TO MONITOR IN-FIELD PERFORMANCE

To monitor is to look, identify, and record.

Monitoring is part of effective crop management. You can measure product effectiveness, reduce costs, and help reduce environmental impacts by monitoring before and after application.

If you have recently applied a pesticide to your orchard, vegetable or field crop, take the time to see how well it worked.

If it's an **insecticide**,

- scout the field or orchard, or if you prefer have a trained scout do it – it's one good way to see if you obtained your money's worth from the treatment.

For **herbicides**,

- monitoring the weed control effectiveness will help you this year (perhaps you need to re-spray) and next year (knowing your weed escapes).

To **monitor:**

- brush up on your weed and weed seedling identification skills
- take a random walk through a field
- look at all areas for a particular weed problem
- record what you see
- take representative samples to determine current levels of pests.

It's important to sample correctly and regularly to get an accurate picture of the problem. You may conduct visual counts or use traps. Refer to the Best Management Practices book on *Integrated Pest Management* for specific monitoring details.

APPLICATION

MONITORING AND MINIMIZING IMPACTS ON NON-TARGET ORGANISMS AND HABITATS

Perhaps the best way to reduce impacts off-target is by using best management practices for pesticide application so the product hits the target pest.

It's a good management idea to make notes on the product used, the location of pest/weed infestations, application rates, weather conditions at time of and after application, effectiveness of application, and environmental effects. This will help you determine whether the product is staying on the crop, or if it's moving off target.

Environmental effects of pesticide applications outside the crop can provide clues to improper equipment calibration or poor application conditions.

PRE-APPLICATION MONITORING

If your pest problems are not known, survey your crop to determine the extent and location of various pests. There is no point to spraying if the problems don't exist.

Also, note the proximity of potential environmental hazards – ponds, streams and other habitats that may be affected by your application. Look into product alternatives that have fewer off-target risks and lower toxicity.

Survey before spraying – know the type and location of pests prior to application.

POST-APPLICATION MONITORING

How to monitor:

- survey fields two or three days after application while observing re-entry restrictions
- look for pest/weed/disease infestation levels, and the degree of control
- look for crop damage – this will depend greatly on the product used
- look for visible pesticide residues such as granules left on the soil surface and at end of rows.

Two or three days after application, check fields to verify that control targets were met.

APPLICATION

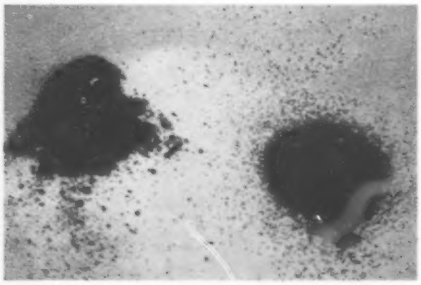
Is the product moving off the target crop? After spraying, is there any chance it moved towards:

- your family and domestic animals?
- bystanders following application?
- your neighbours' crops, livestock, or homestead area?
- wild pollinators and other beneficial insects?
- surface water or source of drinking water?
- fish, wildlife, or native plants?

Near surface waters, avoid using pesticides that are acutely toxic to aquatic life.

How to monitor:

- when surveying fields, look outside the crop area for damage to wild plants such as white or brown spots on the leaves, or large areas of recently dead or dying plants a week to 10 days post-spray – these signs are an indication that the product has moved off the crop
- survey fields for dead or dying animals or birds 12-24 hours after organophosphate or carbamate insecticide applications – the Canadian Cooperative Wildlife Health Centre maintains a number to call for reporting disease and mortality in wildlife
- examine ponds and the shorelines of streams for dead fish or frogs.



As discussed earlier, surface broadcasting of granular formulations can be mistaken for grit by birds that use it for digestion.

The product label gives information about hazards to surface water.

APPLICATION

CHECKLIST FOR REDUCING THE EFFECTS OF PESTICIDES ON WILDLIFE

If there is a choice, select pesticides that are less toxic to fish and wildlife.

☑ Application techniques that reduce wildlife exposure to pesticides are the same as those used to reduce human exposure, environmental damage, crop damage, and waste of expensive chemicals through over-application.

☑ When purchasing products, read the label, and watch for warning statements about environmental hazards.

Statements to look for include:

- "This product is toxic to birds and other wildlife."
- "This product is toxic to fish."
- "This product is highly toxic to bees."

Choose alternatives if possible.

☑ Never wash spray equipment near lakes, ponds, or rivers.

☑ To avoid pesticide drift into non-target areas, use the pesticide formulation and application equipment that keeps the application on target.

☑ Avoid spraying on windy days; early morning and late afternoon are usually the least windy. If you must spray when windy, make some changes to nozzles, water volumes or droplet size.

☑ Don't apply pesticides if there's a potential for heavy rainfall soon after application. Heavy rains can cause pesticide runoff into bodies of water and excessive leaching of chemicals into soil and groundwater.

☑ If you are applying pesticides near water, leave at least a 15-metre buffer strip between the pesticide treatment area and the body of water to avoid contaminating the water and aquatic organisms.

☑ Be extremely cautious when applying granular insecticides. Many of the insecticides that are most toxic to birds are also attractive to birds, who probably mistake them for food or grit. Careful soil incorporation of granular insecticides is required to reduce this wildlife hazard. Clean up spills that may occur at the end of rows or in rough terrain.

APPLICATION

KEEPING RECORDS

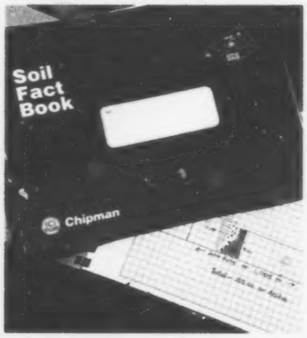
Farmers should monitor and keep records on the type and prevalence of pests in a crop. At application, growers should record:

- pest stage
- crop stage
- wind speed and direction, temperature, soil temperature, relative humidity at time of spraying
- date, time of day, field location
- product and rate applied (including adjuvants)
- water rate (volume)
- level of control achieved
- weather conditions for two or three days following application.

This information is invaluable should you have a product performance complaint. Sometimes the number of pests is not large enough to need control, or the pests may become established in the crop when they can no longer do it any harm. The cost of a pesticide application may be more expensive than the damage that could be done by the pests.

Records will prove useful later when trying to decide on:

- re-entry
- harvest dates
- time of next application
- equipment settings
- application rates
- trouble areas.



Keep records of pesticides applied and conditions that existed during application.

Records of pesticide use will help to protect you and your investment by providing documentation if a question or problem arises from an application. Just as important is the task of observing any effects on nearby plants, animals, and natural environments.

Pesticide application records will help you to:

- evaluate your results
- improve your pest management practices and efficiency
- avoid pesticide misuse
- purchase only what you need
- establish proper use in case of a residue or crop damage question
- solve application problems
- document your use of pesticides in case of lawsuits
- plan your pesticide needs for the next season, e.g., rotation of pesticides for resistance management.

WHEN APPLYING PESTICIDES, BE PROFESSIONAL

It's simple to make positive changes to your pesticide application system, and the benefits far outweigh the small investment of time and effort. A safe and effective pesticide application system includes structures, equipment, devices and record-keeping for each job, as well as sound management practices. Following the best management practices in this book will help you to produce crops safely and economically while protecting the environment.

Acknowledgements

The Best Management Practices project was funded by Agriculture and Agri-Food Canada through Green Plan, managed by the Ontario Federation of Agriculture, and supported by the Ontario Ministry of Agriculture, Food and Rural Affairs.

Special thanks to all those who contributed to this publication by lending their expertise and resources.

The following acronyms will appear throughout the list of contributors:

AAFC = Agriculture and Agri-Food Canada
DOE, CWS = Department of the Environment (Canada), Canadian Wildlife Service
CPIC = Crop Protection Institute of Canada
MOE = Ministry of the Environment (Ontario)
OFA = Ontario Federation of Agriculture
OFEC = Ontario Farm Environmental Coalition
OMAFRA = Ontario Ministry of Agriculture, Food and Rural Affairs
TFIO = The Fertilizer Institute of Ontario

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Graphic Design: Neglia Design Inc.

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ISBN 0-7778-6147-X

Printed 1998

Canada